H. O. PUB. No. 593

MANUAL

OF

COASTAL DELINEATION FROM AERIAL PHOTOGRAPHS

UNITED STATES NAVY DEPARTMENT
HYDROGRAPHIC OFFICE

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OF

COASTAL DELINEATION FROM AERIAL PHOTOGRAPHS

BY

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PREFACE

This manual has been prepared by Mr. P.G. McCurdy, Chief of the Photogrammetry Section, U.S. Navy Hydrographic Office, for the primary purpose of aiding the photogrammetric engineer in the delineation of coastal areas from aerial photographs. It is hoped that this will also lead to a better understanding of the coastal delineation problems in which the photogrammetric engineer, the hydrographic engineer, and the cartographic engineer have a common responsibility.

The description of coastal types and the processes that develop and modify them have been compiled largely from information obtained from the excellent books on the subject by D.W. Johnson in "Shore Processes and Shoreline Development", and by A.K. Lobeck in "Geomorphology". Other data contained herein is based on years of experience by Hydrographic Office personnel, whose valued help in preparing this material is duly acknowledged. Acknowledgment also is made for the constructive criticism by the U.S. Naval Photographic Interpretation Center.

/s/ R.O. Glover
R.O. Glover,
Rear Admiral, U.S. Navy,
Hydrographer.

CONTENTS

CHAPTER I

INTRODUCTION

This Manual is intended for use by photogrammetrists, hydrographic engineers, and cartographers, particularly for those who are delineating coastal areas from aerial photographs and for those who are using that delineation in compiling coastal charts. The purpose is to promulgate the elementary principles involved in coastal delineation in a manner that will aid the photogrammetrist in recognizing some of the characteristics of the natural features that are viewed on the photographs and thereby make it possible to delineate and symbolize those features in a more intelligible and systematic manner. An attempt is made to emphasize the vital need to establish a common ground of general knowledge of the physical processes that produce and alter the landscape. In other words, it is hoped that this will result in making the photogrammetrist "hydrography conscious", and in turn make the hydrographic engineer "topography conscious" by helping him understand some of the problems of the photogrammetrist. It should be realized that without complete hydrographic data from actual surveys it's extremely difficult to interpret the characteristics of many shore and offshore features, such as, the existence of small pinnacle rocks, the amount of water over shoal areas, whether reefs uncover at low water and, to some extent, whether the beaches are made up of sand, gravel, boulders or a combination of all. For the photogrammetrist to properly interpret these features, it is essential that the hydrographic engineer annotate field photographs so as to clarify their interpretation in the office. Therefore, it is hoped that this manual will develop a better understanding of the problems of "Coastal Delineation from Aerial Photographs" and will result in better charts for peacetime navigation as well as for wartime amphibious operations.

The subjects to be discussed relate more specifically to the problems of the photogrammetrist, but also contain the thought of assisting the cartographers in combining the photogrammetric work with the hydrography. It is essential, therefore, that the cartographer become familiar with the symbols placed on the photogrammetric manuscript sheets so that he will be able to combine this information with the hydrography. It should be observed that some of the foreshore and offshore features taken from the photographs are of an indefinite nature and must be combined with the hydrography with this understanding in mind. First, a few terms and definitions are given so that every one will speak a common language. Second, a very general discussion of the geological processes that are involved in developing the shore profile of the different types of coasts are given, with the thought that even a limited knowledge of coastal types will aid somewhat in discovering and interpreting the different features on the photographs. It must be remembered that this is in no way a treatise on geomorphology nor the most complete application of geological principles to the classification of coasts. A few general processes are briefly stated and exceptions are to be expected. In other words, after some degree of application and practice one can gain familiarity with the geomorphic aspects of the more general types of coasts and their associated characteristics. However, one can rarely feel positive of any geological classification of an area photographed from the air unless he is a geologist of considerable experience. Third, a list of the coastal items to be mapped is given along with a description suf-

ficient in detail so that the features may be recognized on the photographs. The fourth section of this manual is devoted to the manuscript symbols which have been recommended to the Joint Map and Photo Committee for use in symbolizing the shoreline and offshore features. Fifth, a recommended procedure is outlined for delineating the coastal items to be mapped and for transferring these features from the photographs to the manuscript sheets. This procedure is the result of many years' experience by personnel of the U.S. Navy Hydrographic Office and it is believed that if it is carried out, a more accurate chart of coastal features will result. Aerial photographs, illustrating coastal types, coastal items, delineation problems, delineation procedures, etc., have been used profusely as it is a well founded theorem that a few selected photographs give a better description than volumes of words.

Frequently, the photogrammetrist is working along coastal areas for which no adequate chart of hydrographic data is available for reference. He has to rely largely upon the information that the field hydrographic engineer finds time to add on the photographs or notes in the field book as well as his own experience in properly interpreting the shoreline and offshore features. It is recommended that the photogrammetrist acquire the habit of reading what the Coast Pilots and Sailing Directions have to say about the particular coast on which he is working. These publications including classified intelligence reports contain much information that will help in classifying the type of coast and, therefore, help in the interpretation of the photographs.

CHAPTER II

DEFINITIONS

Many authors and speakers, in literature or discussions about coastal areas, have a great habit of interchanging the names of the conformations to the extent that it is very difficult to follow their thoughts. Therefore, it's believed desirable to begin this manual with a definition of the coastal terms used herein so that when the reader sees the words: foreshore, backshore, offshore, etc., a definite area along the coast will come to mind.

It should also be impressed on the reader that the defining limits listed herein, and illustrated in Figures II-1 and II-2, are not to be presupposed as representing the official opinion of the Hydrographer or the Navy Department. These areas are defined in this manual for the express purpose of aiding the reader to visualize a definite area when any of the following terms are used:

COAST:— The general area between land and sea.

SHORELINE:— The high water mark of the coast.

FORESHORE:— The zone between the high water mark and the low water mark, or any area along the coast that covers at high tide and uncovers at low tide, as illustrated in Figures II-1 and II-2.

OFFSHORE:— The zone from the low water mark to an indefinite distance seaward, or the seaward area that never uncovers at any tide.

BACKSHORE:— The zone between the shoreline and marine cliff.

MARINE CLIFF:— The seaward edge of the wave-cut cliff that lies nearest the sea, which may vary in magnitude from an inconspicuous slope to an escarpment hundreds of feet high.

BEACH:— The zone from the low water mark to the inland limit of the wave-deposited debris.

Along many of the coasts of the world, the high water mark of the sea will be on the marine cliff, in which case there will be no backshore area and the landward edge of the beach will be the marine cliff which will also be the shoreline. In other areas where the coast is exposed to heavy wave erosion and weathering, the marine cliff will recede a considerable distance from the shoreline and the deposit of debris will at times be against the cliff and, at other times, at varying distances between the cliff and the shoreline.

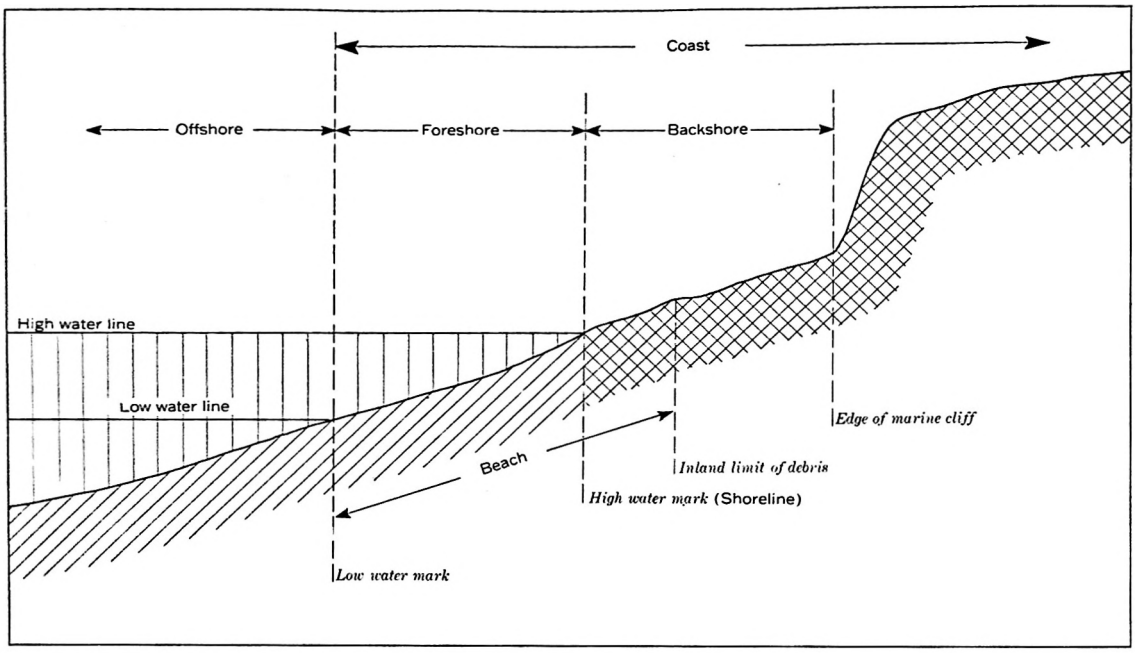


FIG. II-1. Diagram defining the limits of coastal features.

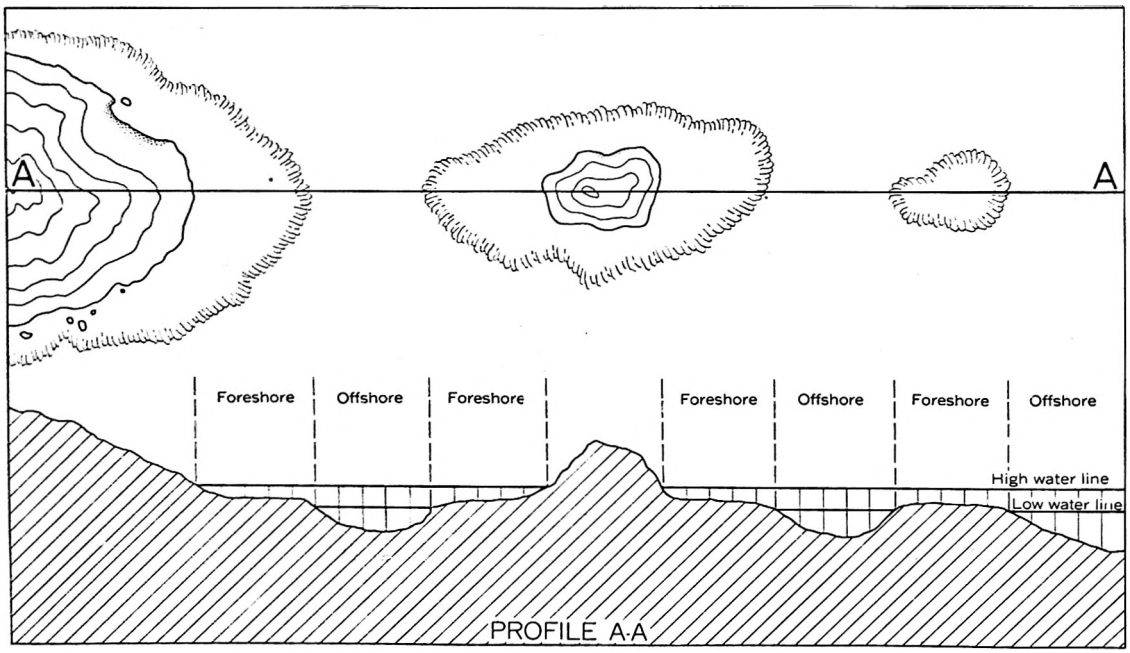


FIG. II-2. Diagram further clarifying limits of features discussed in this manual.

CHAPTER III

TYPES OF COASTS

Doctor John Q. Stewart, Princeton University, states in "Coast Waves and Weather", published in 1945 by Ginn and Company, that when geological principles are applied to the classification of coast lines, eleven principal types may be described as being useful to the navigator. It follows that even a limited familiarity, should be of similar value to those interested in the production of navigational charts and related data.

Without going into the refinements of processes that Dr. Stewart indicates, since refinements are likely to become involved, the coast lines in this manual are divided into four major types. Three of these are subdivided into two or more subtypes. Two other types have been added, although they are not derived from geological principles, for they are of interest to the photogrammetrist and others making hydrographic surveys. A short discussion of the ages of development of some of the types is given so that the reader will be better able to understand the processes and, therefore, be able to recognize the type and to delineate the features on the photographs more accurately.

In the following discussion of types of coasts, the writer has not in any way, tried to introduce anything new. The information given may be found, and much more elaborately covered, in any good book on Geomorphology, such as the publications on that subject by A. K. Lobeck, "Shore Processes and Shoreline Development" by D. W. Johnson, and "Principles of Physical Geology" by A. Holmes.

The four major types of coasts are: I, Emergent - where the land adjacent to the sea has been elevated by deformation or where sea level has fallen relative to the old shoreline; II, Submergent - where the land adjacent to the sea has been depressed or partially drowned or, submerged relative to sea level; III, Neutral - where essential features of the coast depend on some process such as land building and are indapendent of either the recent submergence or emergence of a former land surface; IV, Compound - where the essential features are a combination of two or more of the preceding types.

Two other coastal types, not derived geologically must be considered: V, Vegetative types in which the shoreline is bordered with vegetative growth such as Nipa Palm, Wild Cane, Rain Forest, and Mangrove; flora of this kind complicate the problem of correct shoreline delineation; and VI, Man-made shoreline, such as harbor areas, breakwaters, causeways, seawalls, piers, and docks. A seventh type - Ice cap or ice barrier - of coast should also be carried in this Manual. Due to insufficient knowledge on this subject, it was considered advisable to leave this type out at this time. It will be necessary to revise this Manual from time to time and it is planned to include a chapter on ice barriers at some later date.

For coastal delineation from aerial photographs, it's essential that the photogrammetrist become well acquainted with the six above mentioned types. Four of these types of coasts can be distinguished by application of geological principles of classification and an understanding of these

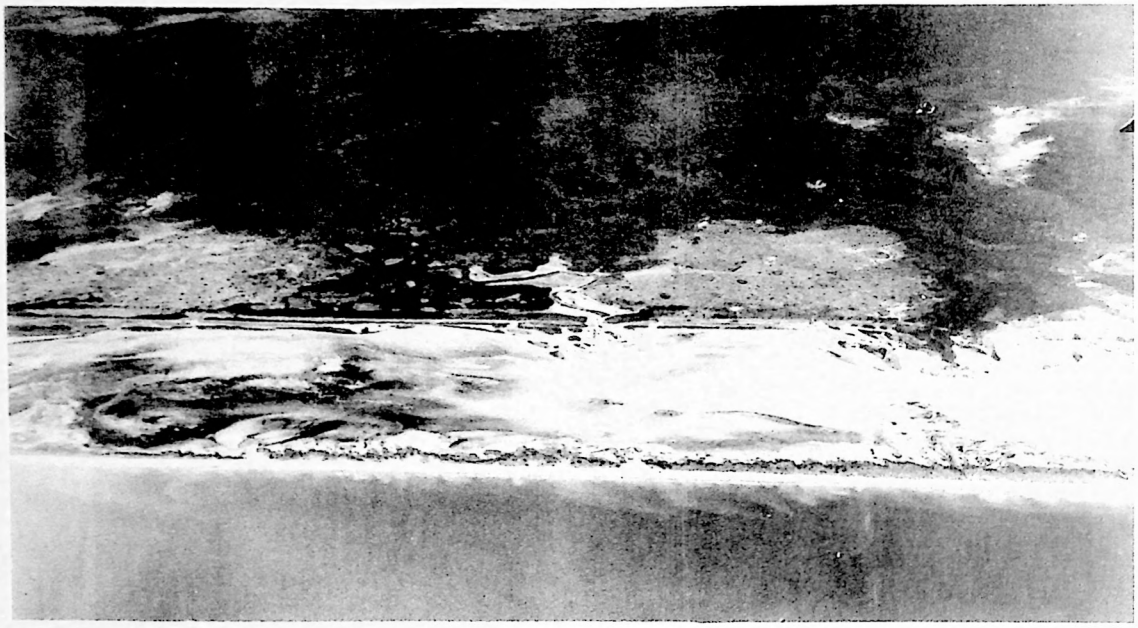


FIG. III–1. Aerial oblique photograph of an emergent coast.

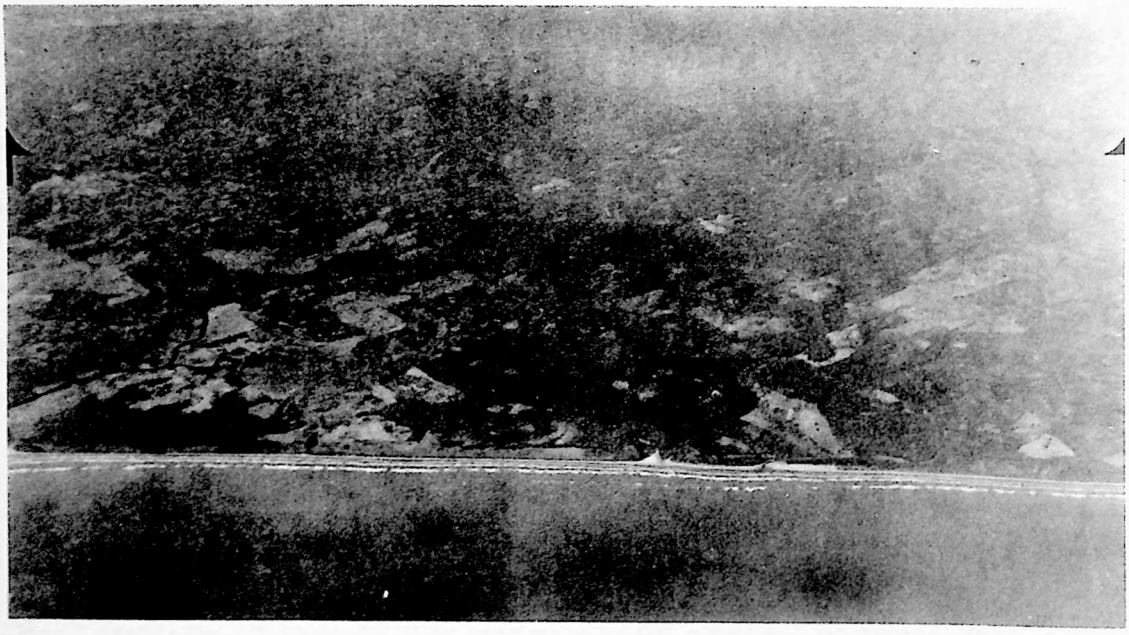
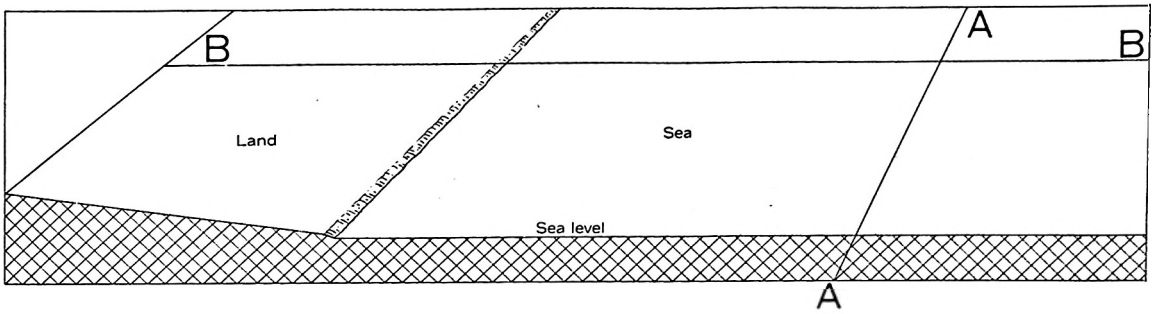
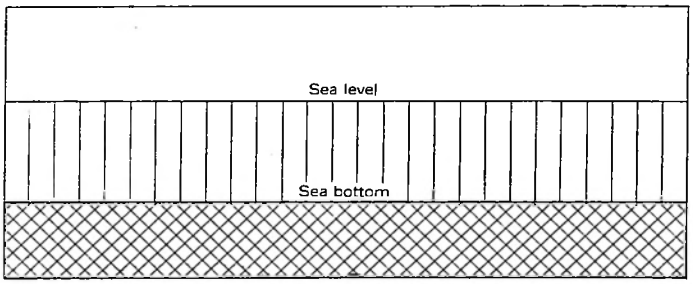
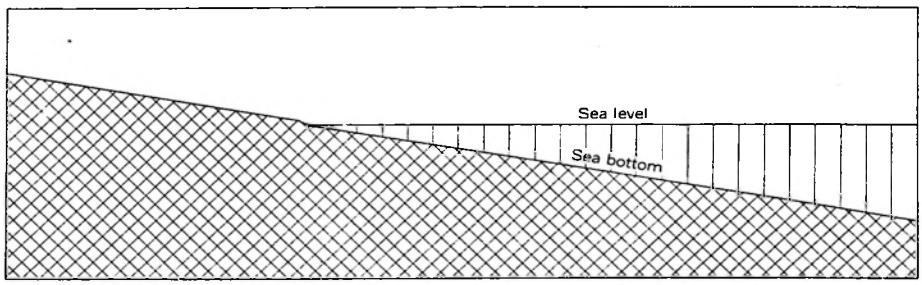


FIG. III–2. Aerial oblique photograph of an emergent coast. This stage of development is older than that shown in Fig. III-1.





PROFILE A-A



PROFILE B-B

FIG. III-3. Diagram illustrating the initial stage of an emergent coast.

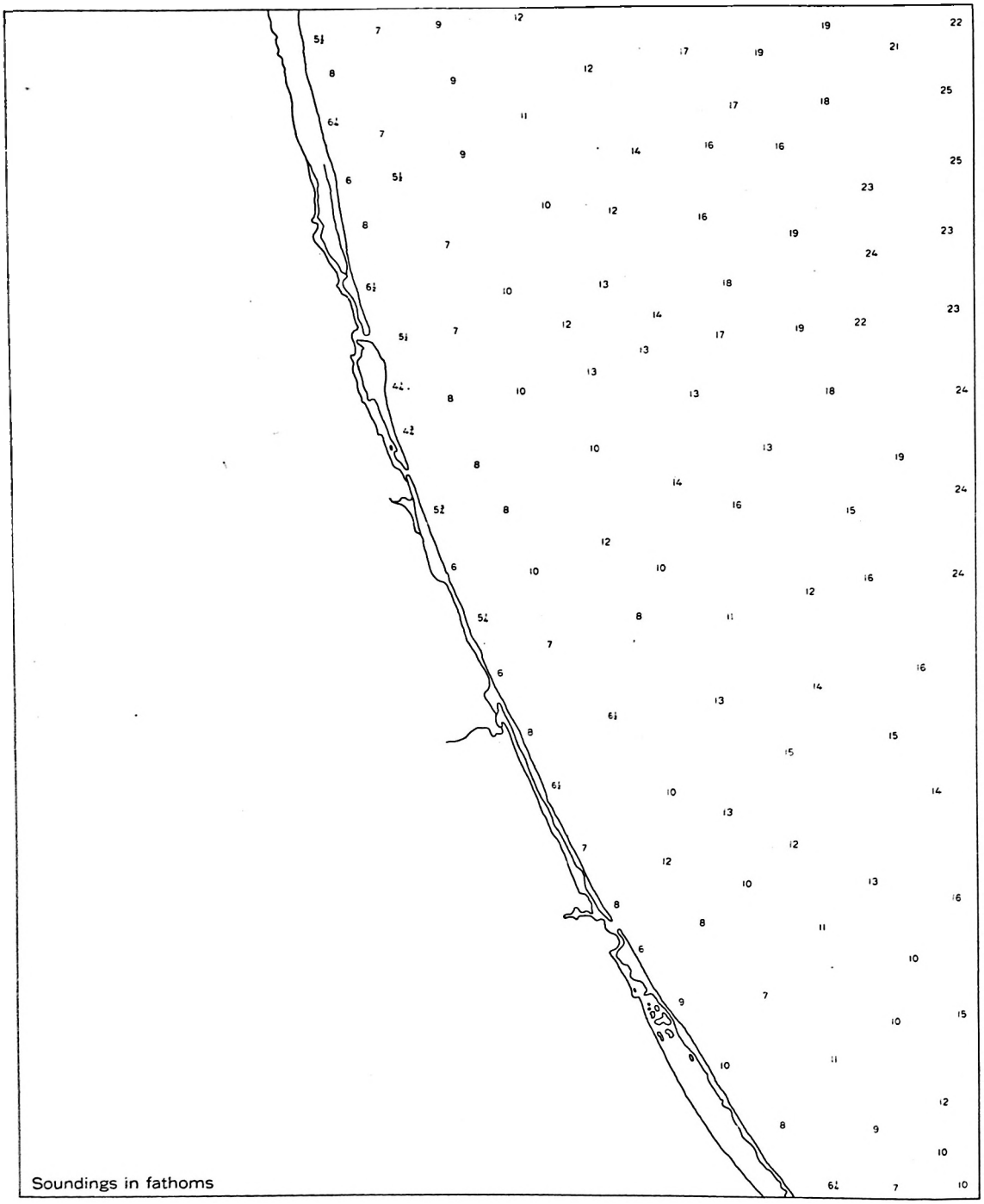


FIG. III-4. Chartlet showing the soundings adjacent to a typical emergent coast. Note the even sloping sea bottom as indicated by the soundings.

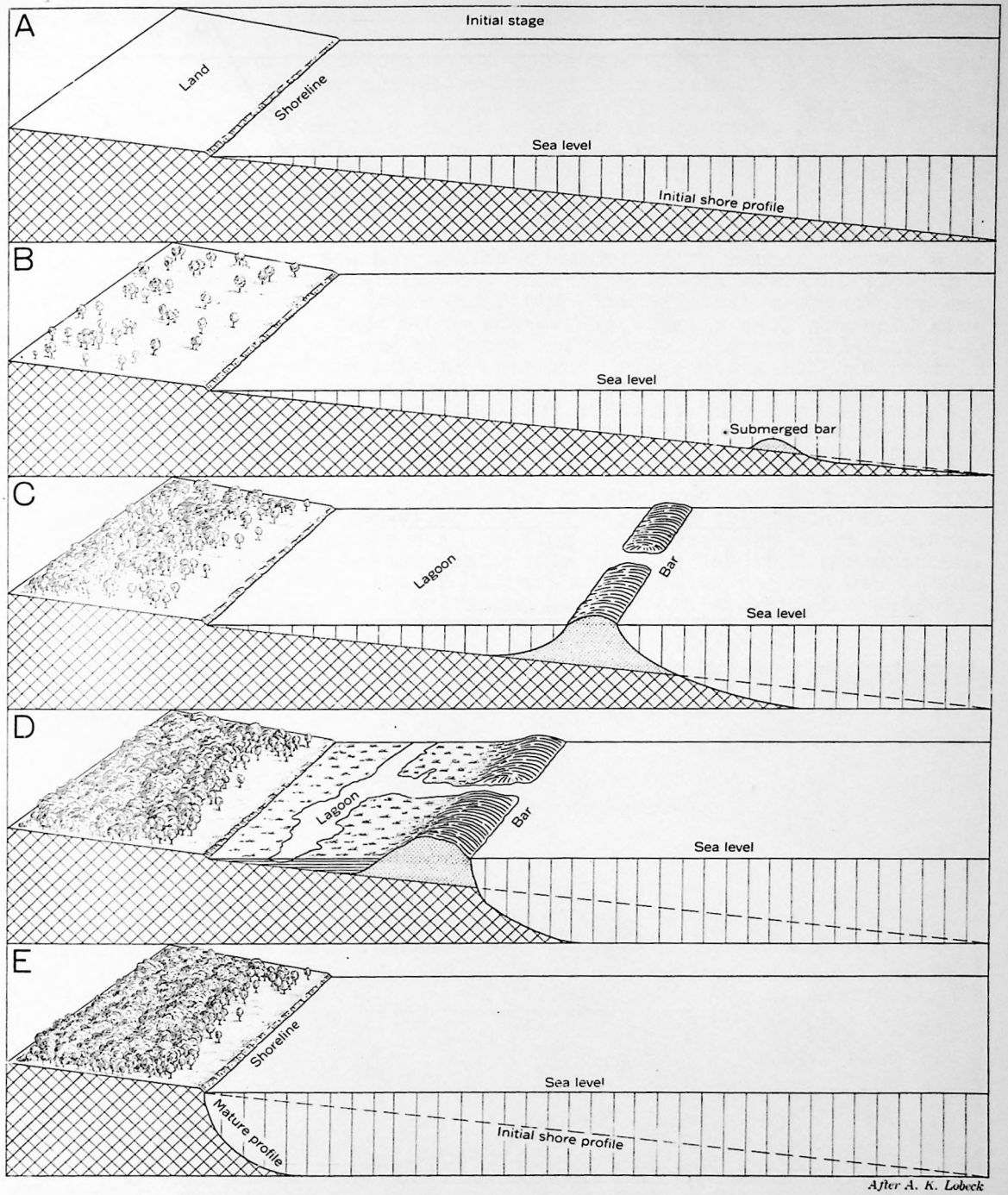
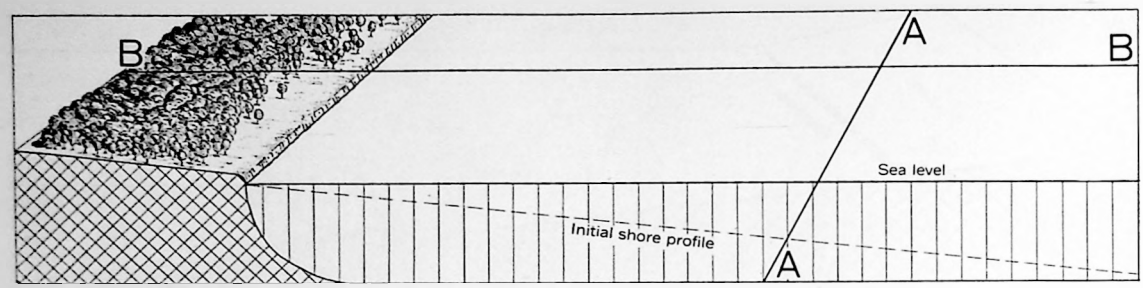
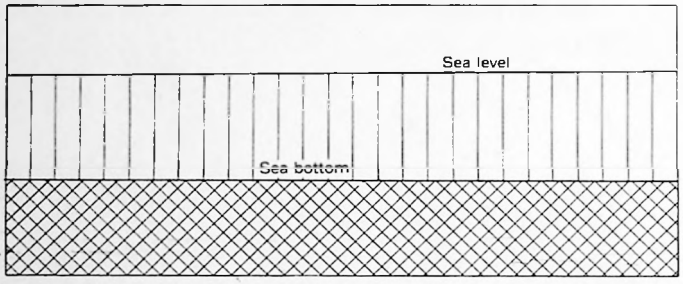
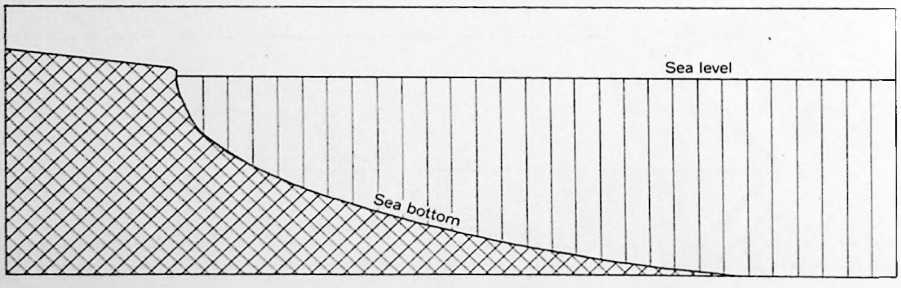


FIG. III-5. Diagram showing the different stages in the development of an emergent coast.





PROFILE A-A



PROFILE B-B

FIG. III-6. Diagram illustrating the mature stage of an emergent coast.

types will aid the photogrammetrist in properly interpreting the shoreline and offshore navigational hazards for use in compiling ordinary navigational charts. The other two types are included in this manual mainly to show the proper symbolization of these features.

1. EMERGENT TYPE :— This type of coast is one where the land mass has been uplifted relative to sea level, due to the warping or tilting of an extensive area of the earth's crust, or by the lowering of the water surface in relation to the older shoreline. In either case, the water surface comes to rest against a portion of the old sea bottom. in most cases, one essential characteristic of such a shoreline is the fact that the bottom of the sea has not been subjected to running water, wind or glacial erosion. Therefore, the shoreline of the emergent type is a straight or a very nearly straight line. The offshore slope of the sea bottom, in the initial stage of emergence, is usually very gradual, giving shallow water for a long distance offshore. Figures III-1, III-2, and III-3 illustrates the initial emergent stage along with a profile parallel to the shoreline and a profile normal to the shoreline. Fig. III-4 is a chartlet showing the soundings adjacent to a typical emergent coast. It will be noted that the soundings indicate an even sloping sea bottom for a considerable extent offshore with no navigational hazards.

Almost immediately after emergence, a submerged bar will form offshore. The precise manner in which the offshore bar originates is a matter of controversy and geologists writing on the subject have advanced various theories for its development. The bar, in the writer's opinion, is developed by a combination of direct wave action on the sea bottom and longshore currents which transport and deposit shore drift material

FIG. III-7. Aerial oblique photograph showing a coastal area that has the characteristics of one that has emerged a number of times. Note the numerous marine cliffs.

along the line of breakers, thus, forming an offshore bar. The gradient of the shore profile usually determines the distance out from the shoreline to where the bar forms. Fig. III-5-B illustrates the forming of the submerged bar. Fig. III-5-C illustrates a later condition where the bar has built up above sea level. This, of course, creates a lagoon between the bar and the shoreline. Small openings in the bar will be kept open by constant flood and ebb of the tide.

In the later stages of the processes developing the shore profile of the emergent coast, the continued poundings of the waves against the bar will gradually push it closer to the shoreline. Tidal currents, streams, and wind will deposit debris, sand, and fine sediments in the quiet waters of the lagoon. In time, these will build the bottom of the lagoon up to a level so that salt marsh vegetation will begin to grow. Fig. III-5-D illustrates this more mature stage of development of the emergent type of coast.

The emergent type has reached its maturity when the lagoon or marsh has disappeared entirely and the bar has been forced back upon the mainland. Fig. III-5-E illustrates this condition of maturity. The shore profile has now been deepened sufficiently so that the wave action is now able to attack the main shoreline. Fig. III-6 illustrates the mature stage together with a profile parallel to the shoreline and a profile normal to the shoreline. Fig. III-7 is a very interesting illustration, showing a coastal area that has all the characteristics of one that has emerged a number of times. This is indicated by the numerous marine cliffs still visible.

The shore profile, after the mature stage, will be changed by wave erosion. The amount of change will depend largely on whether the coast is protected or exposed and on the composition of the shore. In other words, the stability of the shoreline is a condition of approximate balance between erosion, weathering, and the ability of the waves to transport the debris accumulating in front of the shoreline. The photographic illustrations in Chapter VII will show, in some instances, the effect of erosion. For a more thorough and complete study of the development of the shore profile, the reader is referred to the work of D. W. Johnson "Shore Processes and Shoreline Development".

It is essential to remember the following points relative to the emergent type of shorelines:

1. The initial stage is characterized, in general, by an area of coastal plain; by a long straight or almost straight shoreline with few, if any, bays or coves; by very few, if any, navigational hazards except for heavy breakers that would hinder the landing operations of small boats.

2. The period between the initial stage and maturity is characterized by one or more offshore bars; by a lagoon between the bar and mainland; by very few, if any, navigational hazards beyond the outer bar.

3. By the time maturity is reached, the bar has been compressed against the mainland, eliminating the lagoon and bar. Maturity is characterized by a long straight or very nearly straight coast with very few, if any, offshore navigational hazards and by a comparatively narrow beach at the base of a low marine cliff.

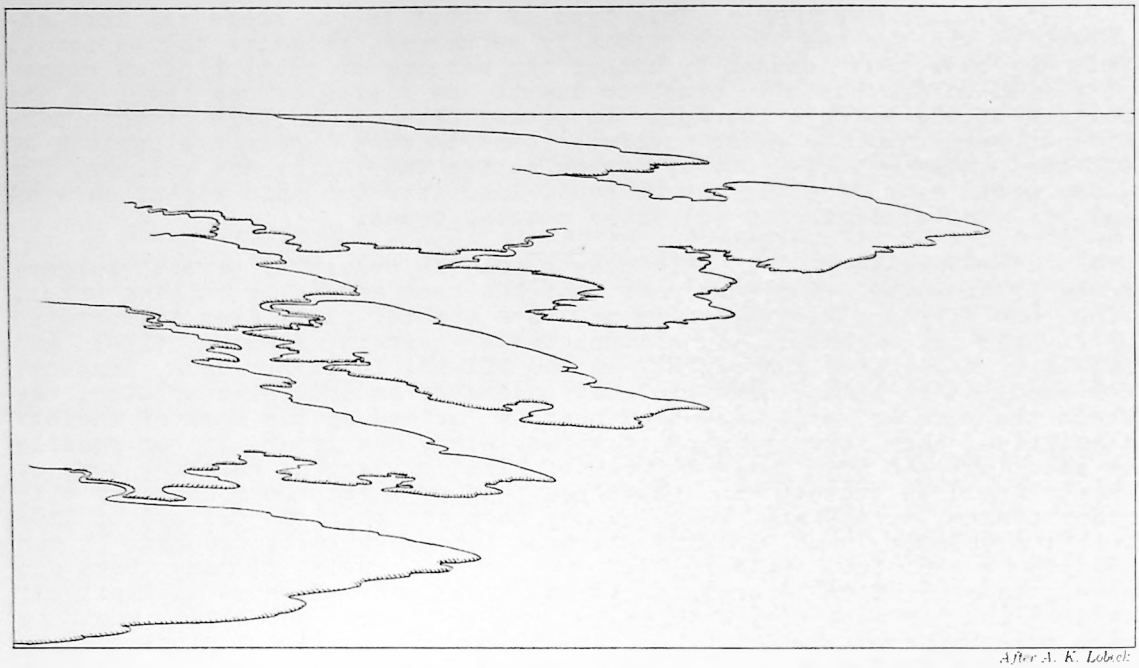
II. SUBMERGENT TYPE:— This type of coast is one where the land adjacent to the sea has become partially submerged, relative to sea level. This may have been caused by either the warping or tilting of an extensive area of the earth's crust or due to the rising of sea level by the melting of the earth's icecaps. In either case, at the time of this partial submergence, the water surface comes to rest against a portion of the earth that has been cut by stream action into hills and valleys. The submergent type of coast may be subdivided into two main types, such as (a) ria coastal areas and (b) fiord coastal areas.

(a) Ria Coasts:— Ria coasts are the result of partial submergence or drowning of a land mass that has been eroded by running water, wind, and frost. This land mass may be a coastal plain area illustrated in Figures III-8 and III-9, a mountainous terrain, Figures III-10 and III-11, or a volcano, Figures III-12 and III-13. In either case, imagine, for example, an inland area that has undergone an extensive erosion: one where the rock and soil have been sharply eroded by the work of ancient glaciation, then later by running water, wind, and frost. It can readily be seen that the area would consist of hills of varying heights, some of which would be rounded and others the tops of which would be rocky with sharp pinnacles, the area being cut by deep and shallow valleys of different gradients. Now, imagine the area being partially drowned. It can readily be seen that this type of coast would consist of many bays and coves, many offshore islands, islets and rocks, many offshore navigational hazards and, in case of a drowned mountainous area, the coast would be very rugged and "steep-to". Fig. III-14 is a chartlet of a typical submergent coastal area. It will be seen that this type of coast is very rugged with an uneven sea bottom as indicated by the soundings, and has many offshore navigational hazards. Fig. III-15 illustrates the initial stage of submergence along with a profile parallel to the shoreline and a profile normal to the shoreline.

The following discussion of the stages of development applies more specifically to the submerged mountainous terrain but it applies, in general, to other types of ria coasts. This type of coast is characterized by its irregularity, consisting of many peninsulas and bays, a profusion of islands, islets and rocks, and by an uneven sea bottom. These irregularities and inequalities represent the former hills and valleys of the much eroded land. Fig. III-16-A.

Waves will immediately attack the exposed headlands and islands causing somewhat the condition illustrated in Fig. III-16-B. The talus or debris that accumulates from the wave erosion against the exposed headlands and islands, and from other sources, is deposited by tidal currents and longshore currents along the shore in the form of spits and bars. This is illustrated in Fig. III-16-C. Some of the debris is carried to the upper end of the bays forming beaches of sand, gravel, and mud, which eventually builds up into bay deltas. The marine erosion in time will eventually wear the islands down entirely and will cut the headlands back farther and farther. At the same time, the bays will be filled causing the deltas to extend out farther and farther. Fig. III-16-D illustrates this stage of development.

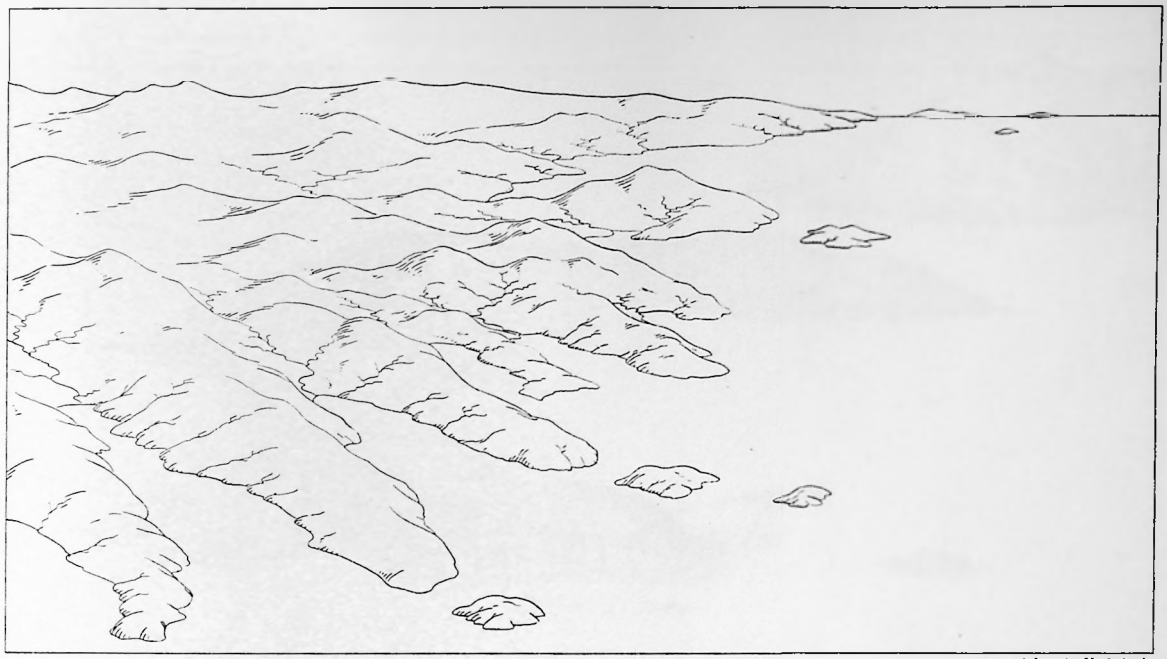
The ria coast is said to be mature when the headlands are cut back and the bays eliminated similar to the condition illustrated in Fig. III 16-E. Fig. III-17 illustrates the mature stage along with a profile parallel to the shoreline, and a profile normal to the shoreline. Fig.



After A. K. Lobeck

FIG. III-8. Diagram illustrating a partially submerged coastal plain.

FIG. III-9. Aerial oblique photograph of a partially submerged coastal plain.



After A. K. Lobeck

FIG. III-10. Diagram illustrating a partially submerged mountainous terrain.

FIG. III-11. Aerial oblique photograph of a partially submerged mountainous terrain.

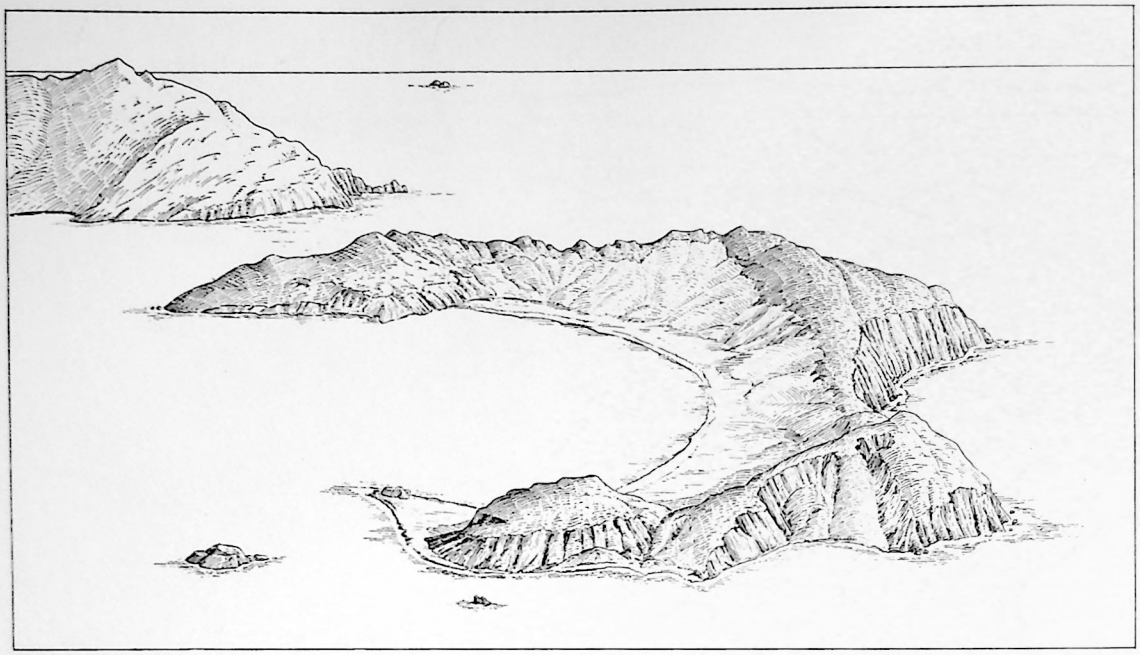


FIG. III-12. Diagram illustrating a partially submerged volcanic crater.

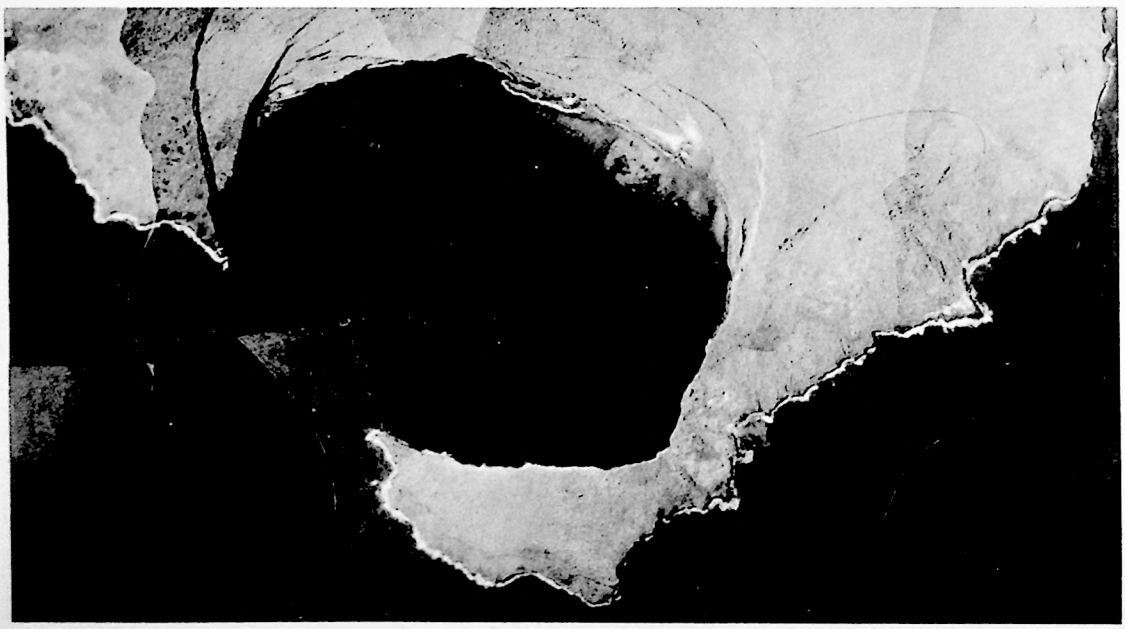


FIG. III-13. Aerial photo mosaic of a submerged volcanic crater.

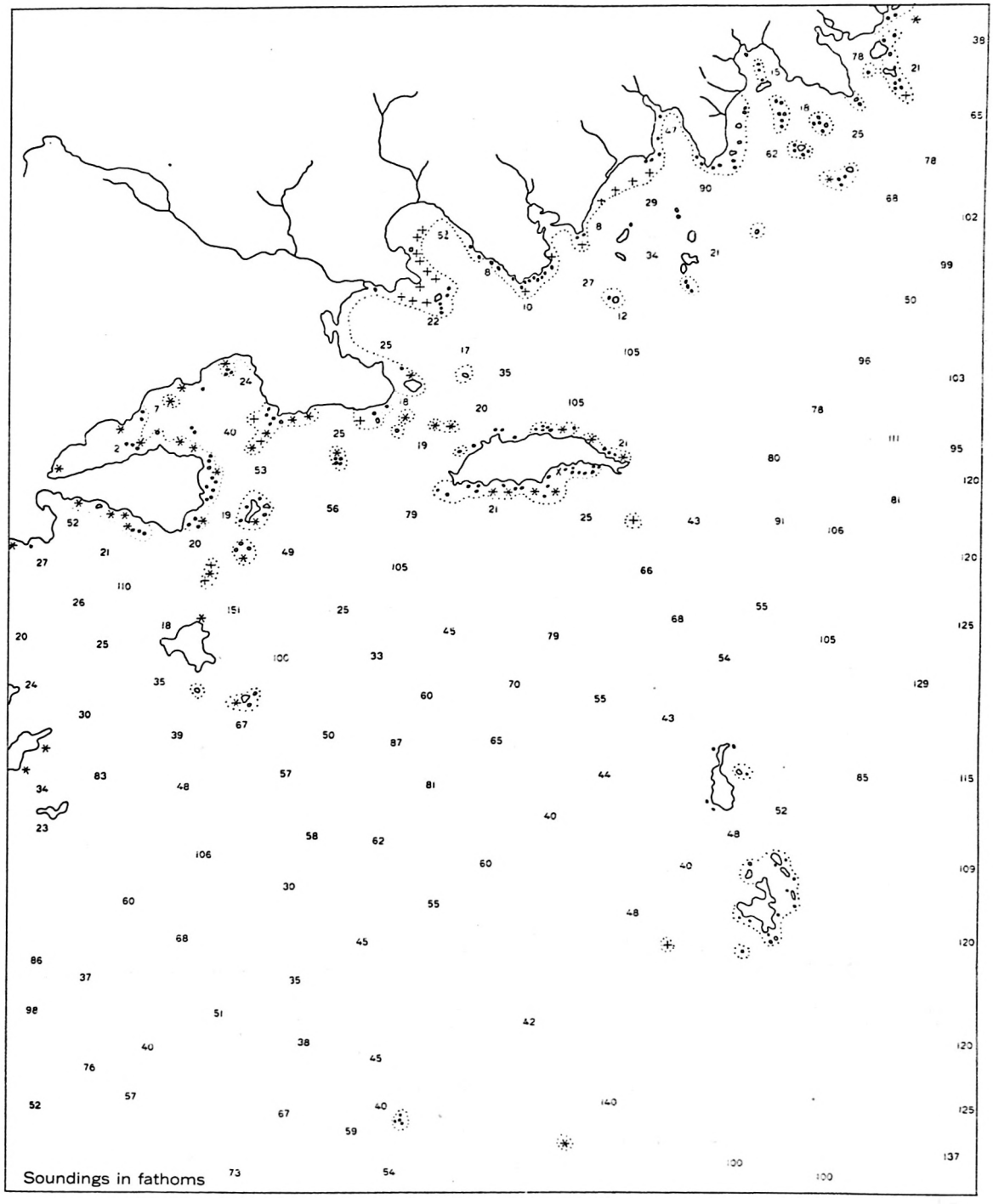
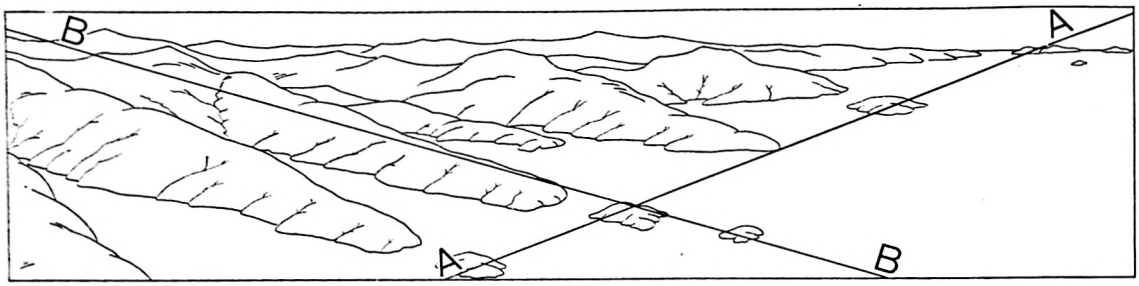
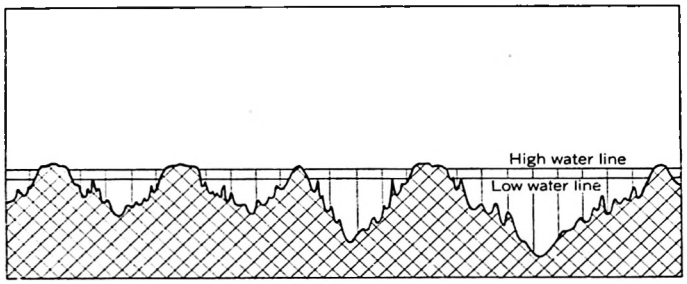
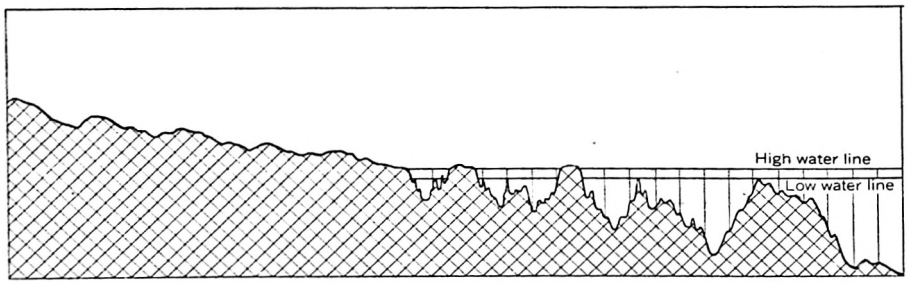


FIG. III-14. Chartlet showing the soundings adjacent to a typical submerged coast. Note the uneven sea bottom, indicated by the soundings and the numerous islands, islets, and rocks.





PROFILE A-A



PROFILE B-B

FIG. III-15. Diagram illustrating the initial stages of a submerged coast.

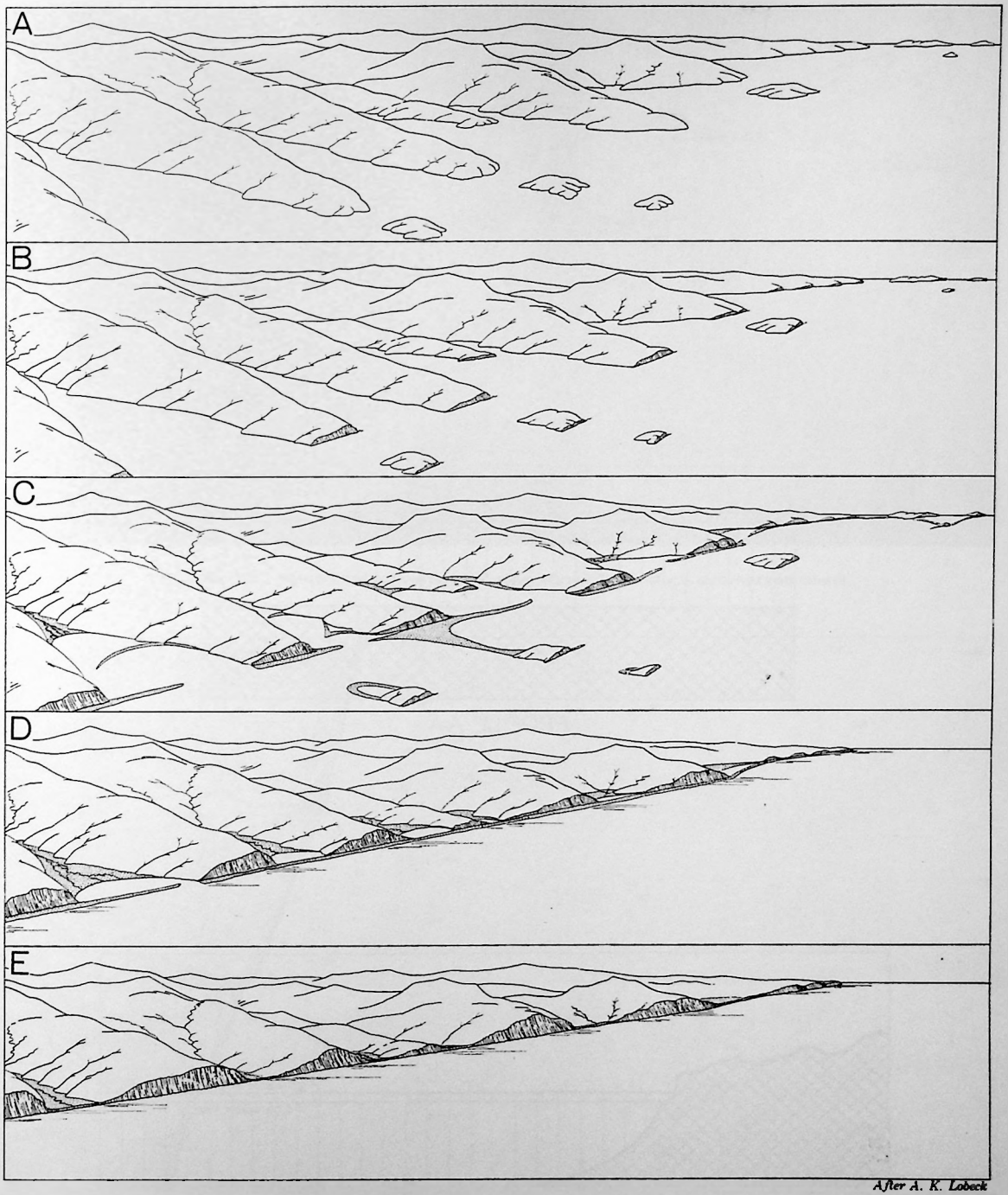
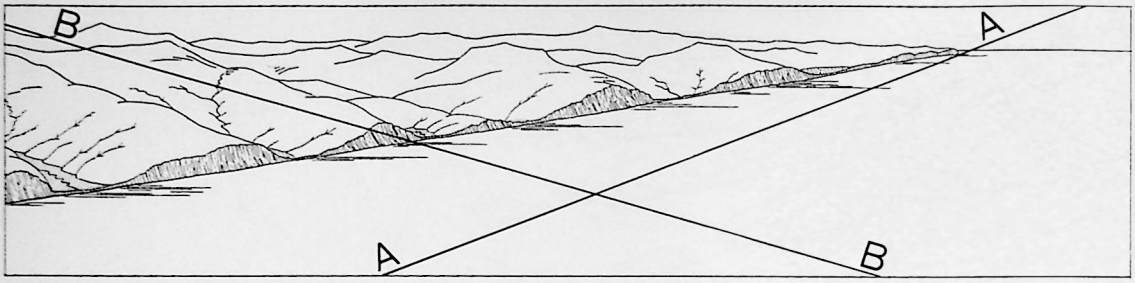
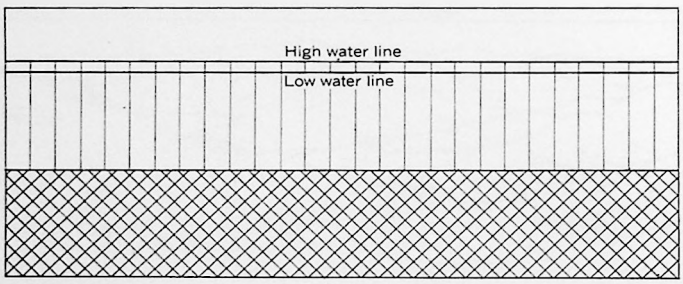
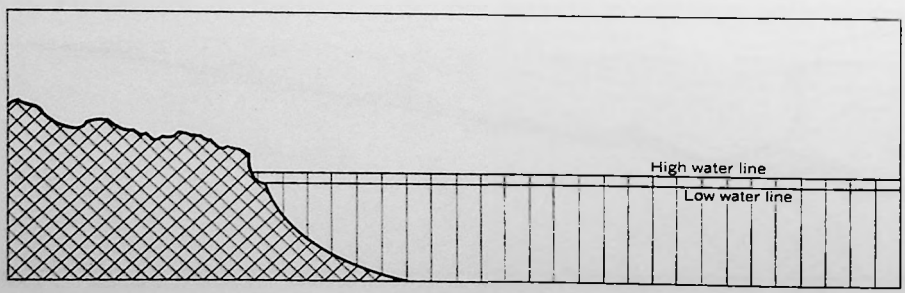


FIG. III-16. Diagram showing the different stages in the development of a submerged coast.





PROFILE A-A



PROFILE B-B

FIG. III-17. Diagram illustrating the mature stage of a submerged coast.

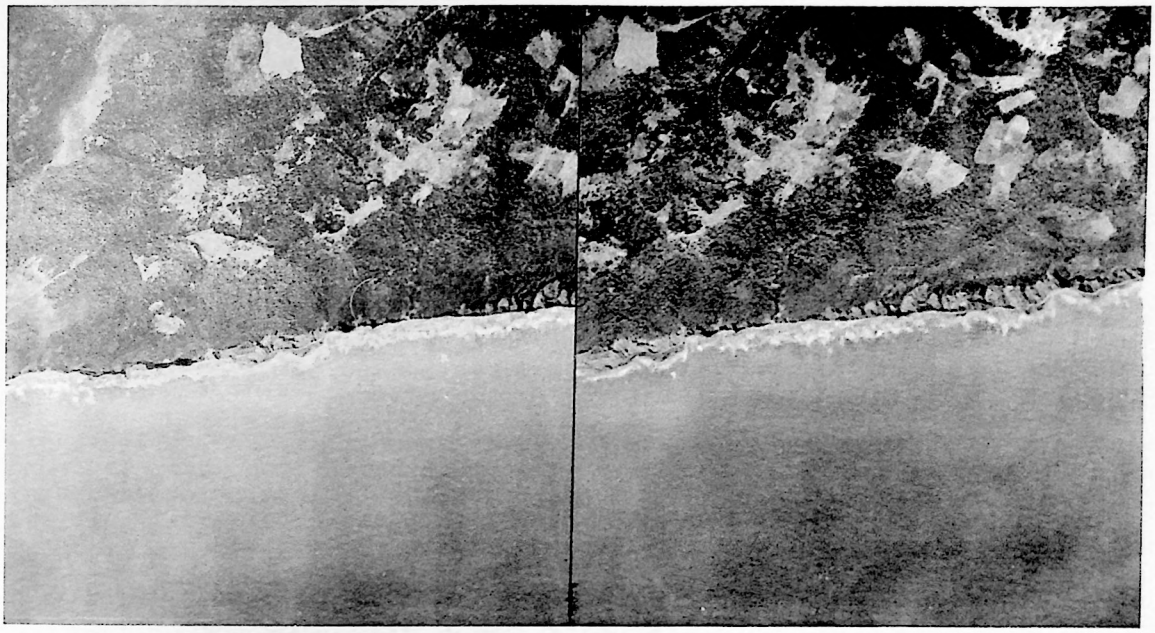


FIG. III-18. Stereo pair of vertical photographs of a mature submerged coast.

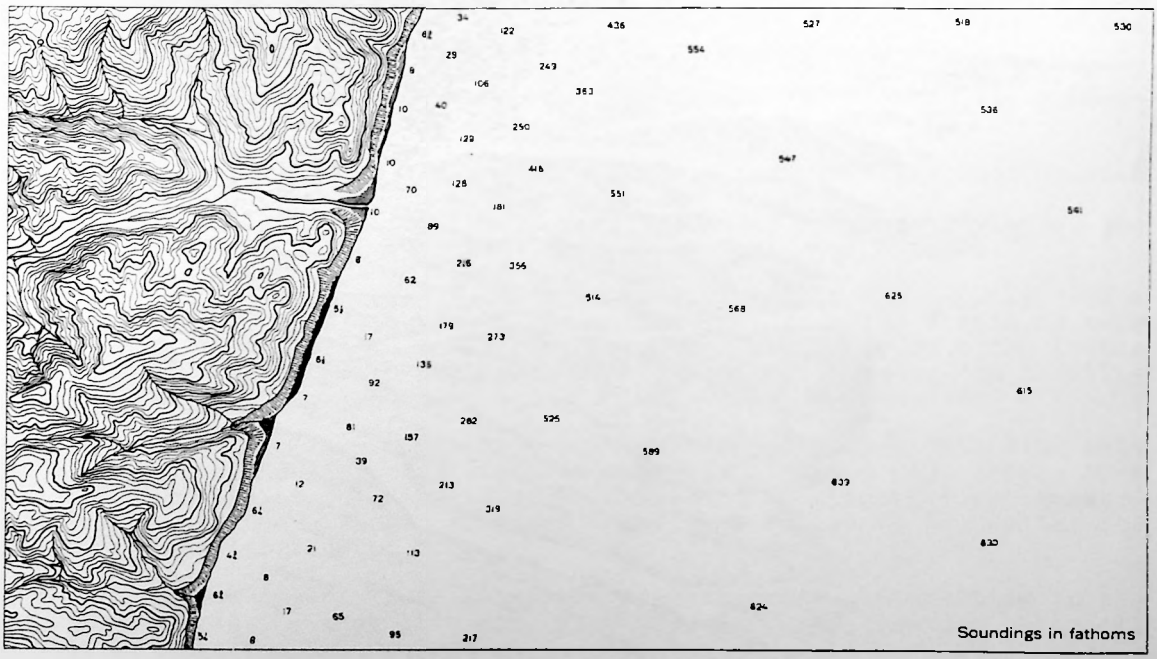


FIG. III-19. Chartlet showing the soundings adjacent to a typical mature submerged coast. Note the deep even sea bottom indicated by the soundings.

III-18 is a stereo pair of aerial photographs of a mature submerged coast, and Fig. III-19 is a chartlet of a typical mature coast. It will be seen that this type of coast is very rugged, "steep-to" and with a very even, deep sea bottom and no offshore navigational hazards.

It must be recognized that the cycle of development of the ria shore profile may be greatly advanced or retarded by the extent to which the area is exposed to heavy wave action. In other words, all stages of development may be apparent along an extensive submergent coast.

After maturity, the development of the shore profile of the submergent coast is essentially the same as for the post maturity stage of the emergent type.

The following points should be remembered relative to the submergent ria coast.

1. The initial stage is characterized by an exceedingly irregular shoreline; by numerous bays or drowned valleys in which deep water is found a short distance offshore; by many peninsulas projecting out to sea; by the presence of numerous islands, rocks, and shoals which represent extreme navigational hazards.

2. Between the initial stage and maturity most of the islands, rocks and navigational hazards have disappeared and spits and bars have formed along the outer edge of the peninsulas.

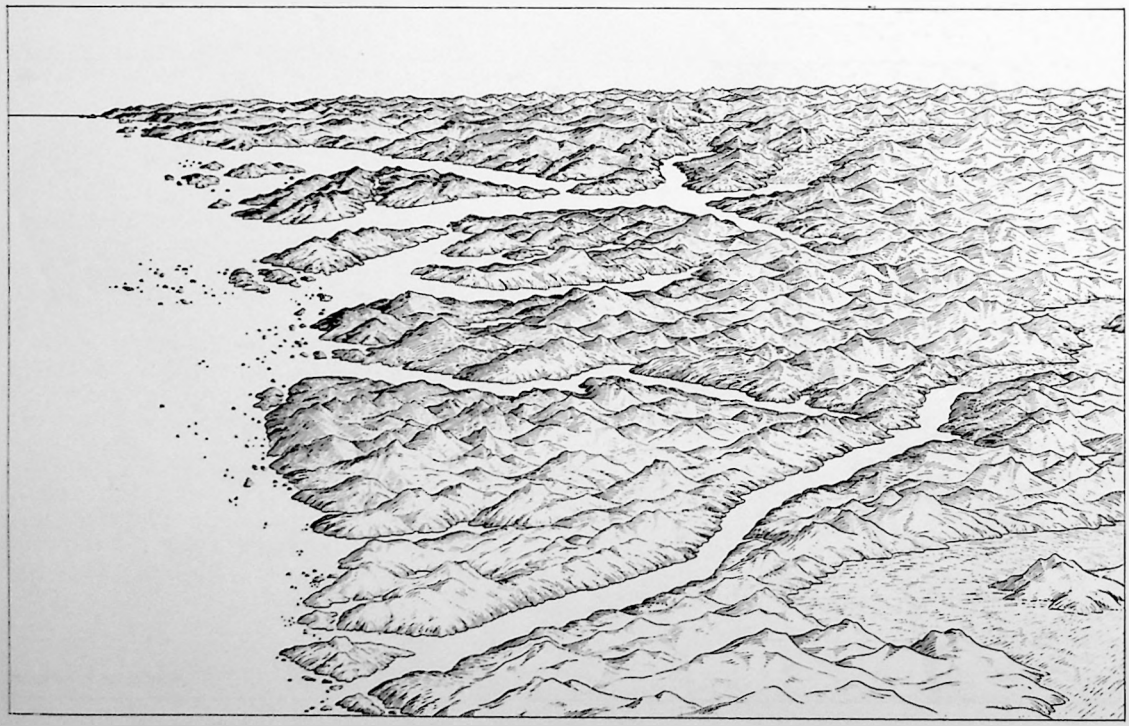


FIG. III-20. Diagram of a typical fiord coast.

3. After maturity very few, if any, offshore navigational hazards remain, and the shoreline consists of a comparatively narrow beach at the base of an almost continuous bold marine cliff.

(b) Fiord Coasts:— The fiords are partially submerged glacial troughs. The long, narrow, deep bays, characteristic of the fiord country, have been channeled out by movements of ice. They may be the results of the channeling effects of the movements of the ice followed by either the land area being tilted downward into the sea or by the sea rising into the cuts once carved by the ice. On the other hand, it is quite possible that the fiords were formed by the glaciers flowing to the sea. They gouged out a valley far below sea level so that when the glacial ice eventually melted, the trough became flooded by the sea. Regardless of how the fiords were formed, it is generally believed that the fiord type is a subtype of the submerged or drowned highland.

The fiord coastal area is made up of long, narrow, deep bays or arms extending for considerable distances inland. The coast lines of the fiords are almost perpendicular, smooth mountain walls, which may rise to great heights. In most fiord coastal areas the water at the entrance to the fiords may be much more shallow than the water inside the fiord. Also the outside coast is usually marked with many islands, islets, and rocks. Glaciers still remain at the head of a great many of the fiords of the world. This is especially true of Greenland. Fig. III-20, III-21, and III-22 are typical examples of a fiord coast and Fig. III-23 is a chartlet of a typical fiord coast. It will be seen that this type of coast is very dangerous for navigation. Although the water is usually deep offshore and in the fiords, the many islands, islets, and rocks off the entrances to the fiord make navigation in these areas extremely hazardous. Figures III-24 and III-25 are excellent aerial views of the numerous offshore navigational hazards along a fiord coast.

The following points should be remembered relative to the submergent fiord coasts:

1. The shoreline inside the fiords are usually very straight smooth lines.

2. The general outside shoreline is very irregular with many islands, islets, and rocks which represent extreme navigational hazards.

3. Present day fiord coastal areas are in frigid zones and usually have a tremendous amount of large and small icebergs floating within or very near the fiord areas. Therefore, extreme caution is required in the delineation process to separate islets and rocks from the floating icebergs.

III. NEUTRAL TYPE:— This type of coast is subdivided into four main subtypes, the essential characteristics of which depend upon causes such as, some process of land building, independent of either recent submergence or emergence. These subtypes are: (a) coral reef, (b) delta, (c) volcanic, and (d) fault.

The first two of these subtypes are extremely interesting to the photogrammetrist as they give him more trouble in delineation than all other types of coast.

(a) Coral Reefs:— The original development of coral reefs is

FIG. III–21. Aerial oblique photograph of a typical fiord coast.

FIG. III–22. Another oblique photograph of a typical fiord coast.

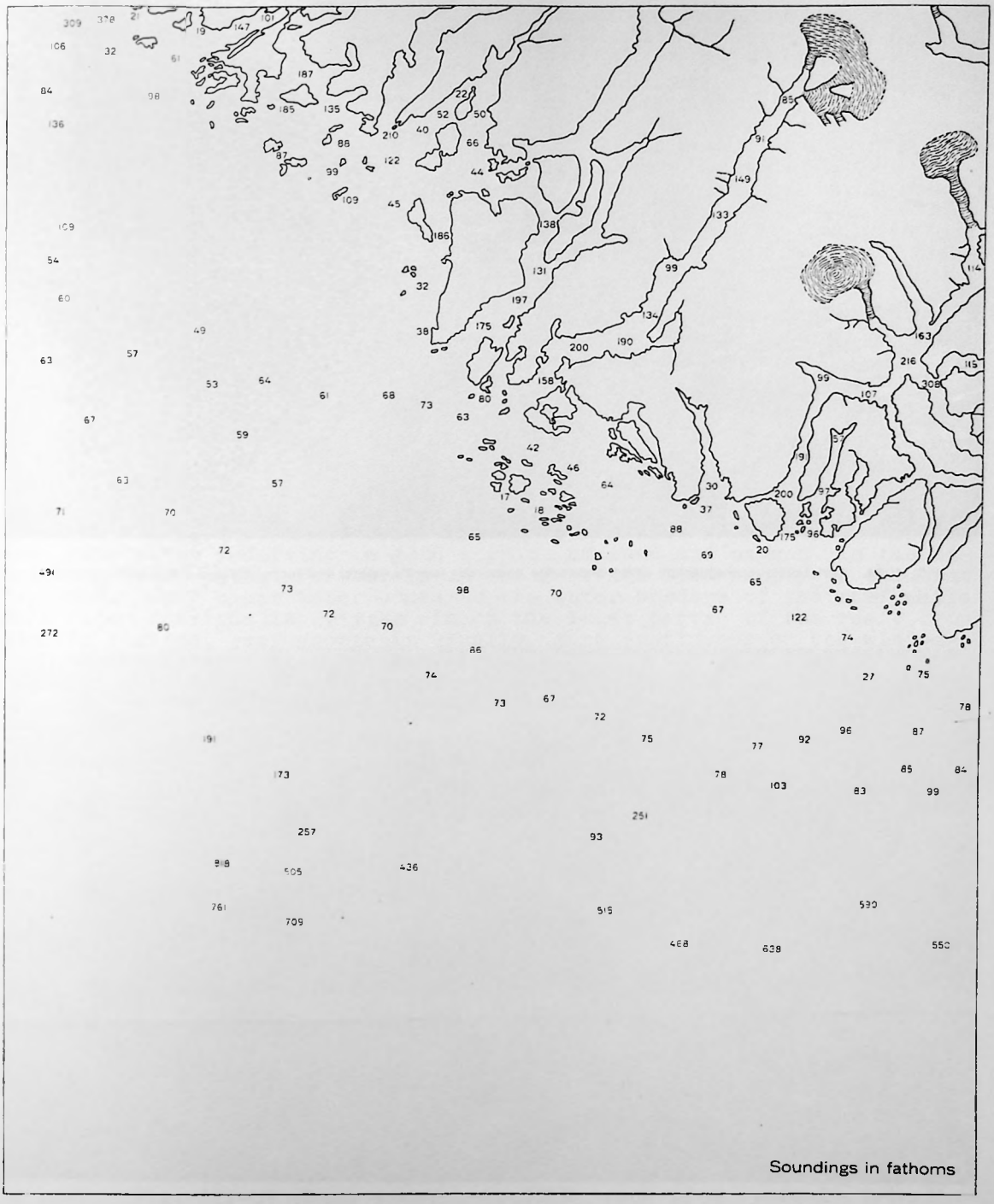


FIG. III-23. Chartlet of a typical fiord coast. Note the deep water inside the fiords and the ridge in the sea bottom at the entrance to the fiords as indicated by the soundings.

FIG. III-24. Aerial oblique photograph which shows the numerous islands, islets, and rocks offshore a typical fiord coast.

FIG. III-25. Another aerial oblique photograph which shows the numerous islands, islets, and rocks offshore a typical fiord coast.

still more or less of a controversial nature, and actually has very little direct relation to the problem of delineation. Coral reefs are the product of a collection of particles by lime secreting organisms, among which polyps, known as corals, and algae, known as nullipores, are the most abundant. The former presumably provide the greatest volume of reef building material, while the latter are believed to be of essential importance in binding the material together on the reef face, so that it will better withstand the assault of storm waves. The reef-building corals extract lime from the sea water and deposit it around their living tissues, forming, in this way, hard coral structures. These structures vary greatly in their size, shape, and character - some are rounded, massive "heads" a few inches to several feet in diameter; others are delicate branching forms of the "staghorn", "elkhorn", and "bush" type, to mention only a few of the many types. When the living coral dies, the skeleton remains standing, so that a coral reef may be "alive" or "dead". Frequently, the reef surface will show none of the standing skeletons. Due to wave action, they have been broken and crushed, and some are ground into coral sand so fine that the original size and shape are completely lost. These pieces may then be compactly cemented together to form a firm "reef-rock". In some areas ancient coral has become converted into crystalline limestone.

Usually the extreme seaward edge of coral formation rises slightly higher than the general height of the reef to form a "lip". This is believed to be because the reef-building organisms on the outer margins are constantly receiving a good supply of food and oxygen in the on-drifting ocean water. Further in on the reef the food supply is somewhat depleted. Only clear water comes to the outer borders of the reef, while much fine detritus is drifted in on the inner parts of the reef. For similar reasons, reef growth is usually more continuous on the windward than on the leeward arc of their circuits. The outer reef edge or "lip", that projects above the surface is also called the "boulder zone" because of a low mound of fragments of shell and coral thrown up by breaking waves.

The growth of these reef-building organisms is possible only in pure sea water of average salinity, of relatively high temperature not less that 68° or 70° F., and the corals are usually limited to depths of approximately 25 fathoms. Coral reefs are found weak or wanting in embayments where stream mouths and deltas are formed, or where conditions muddy the ocean water. Therefore, coral formations are not ordinarily found in latitudes higher than 30° or opposite river mouths. Neither can living coral survive more than brief, infrequent, exposures to the air. Consequently, coral cannot extend their upward growth higher than about the line of Mean Low Water, although pieces of dead coral may be visible above various tide levels. The reader is referred to "The Coral Reef Problem" by W. M. Davis for a comprehensive study and analysis of coral reef development theories.

Coral reefs are grouped in three general classes: Fringing reefs, barrier reefs, and atolls. Fringing reefs lie close against the shore and form platforms - most of which are exposed at low tide. The land may be a small island or a large land mass. The width of a fringing reef may vary from a few feet to a mile or two, although they appear more characteristically as narrow belts. Fig. III-26 shows this type of reef. Fig. III-27 shows a cross-section view of a typical fringing reef and Fig. III-28 is a chartlet of a typical volcanic island with a fringing coral reef. It will be seen that the water offshore is very

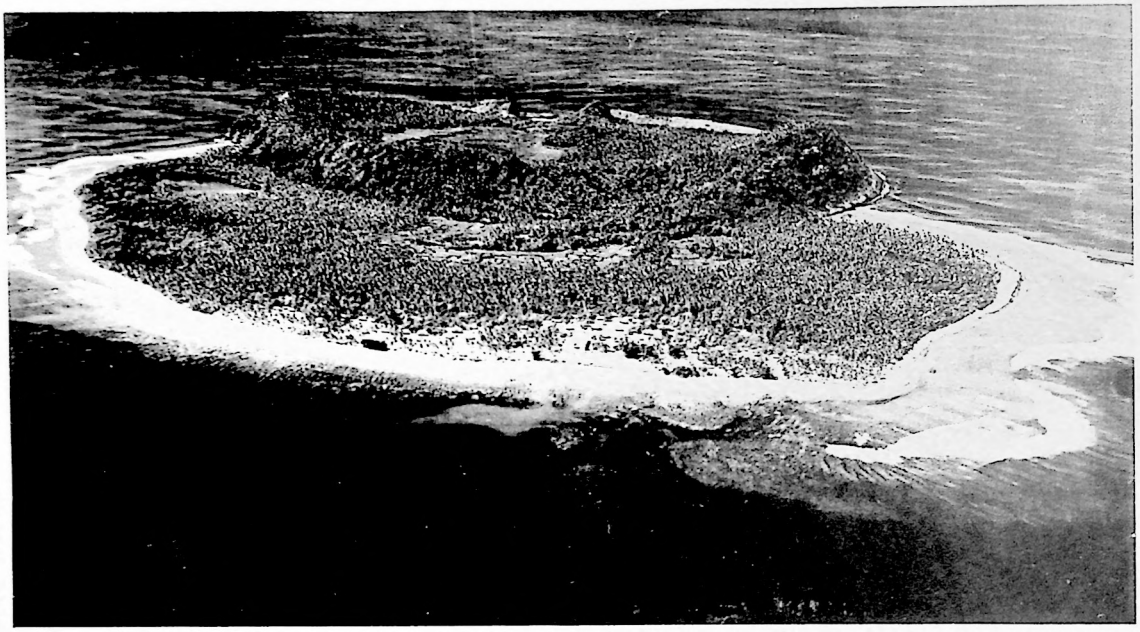


FIG. III-26. Aerial oblique photograph of a fringing coral reef.

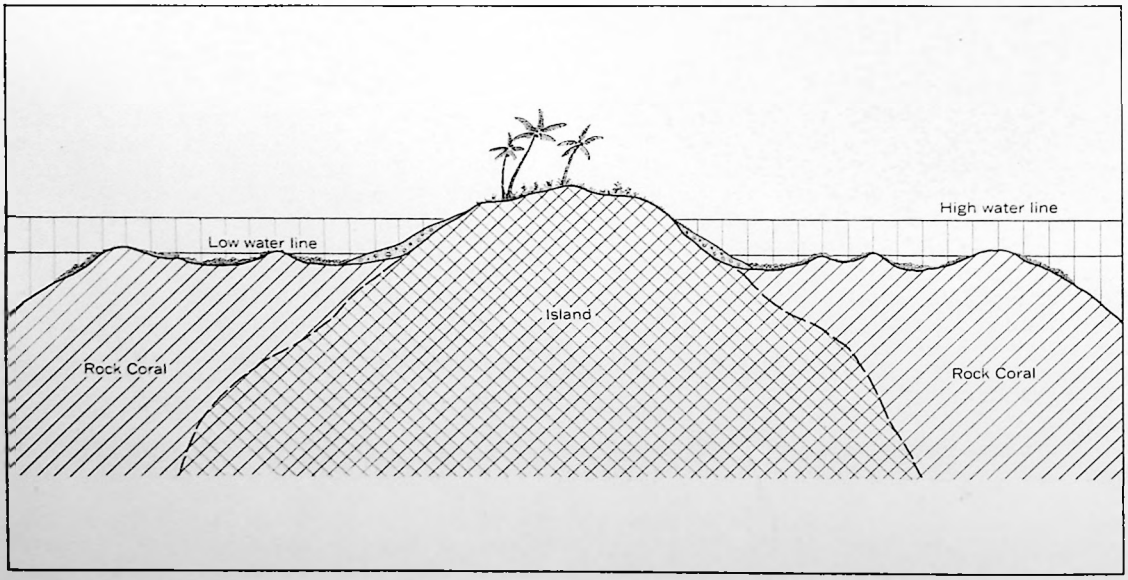


FIG. III-27. Diagrammatic profile of a fringing coral reef.

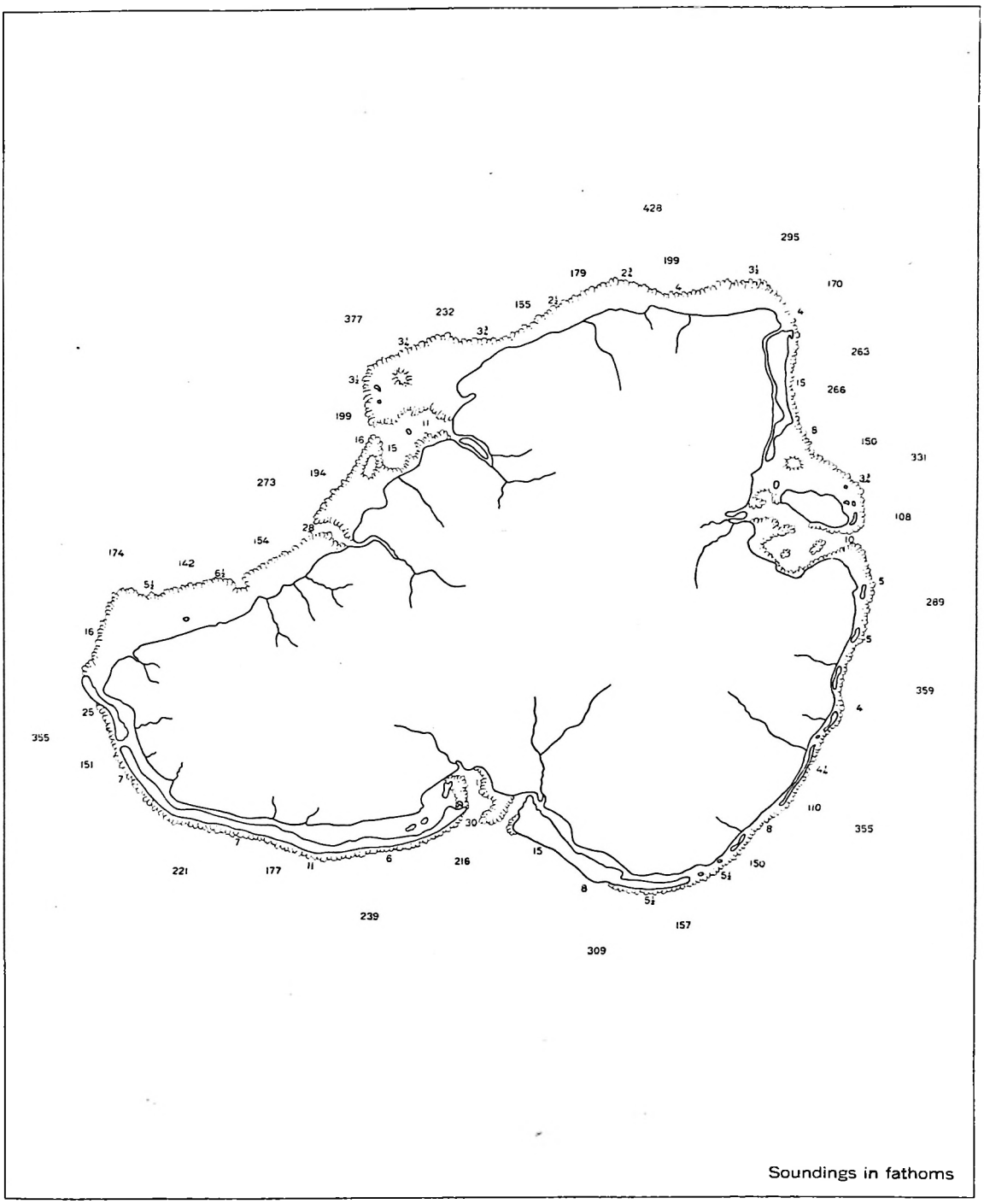


FIG. III-28. Chartlet showing a fringing coral reef.

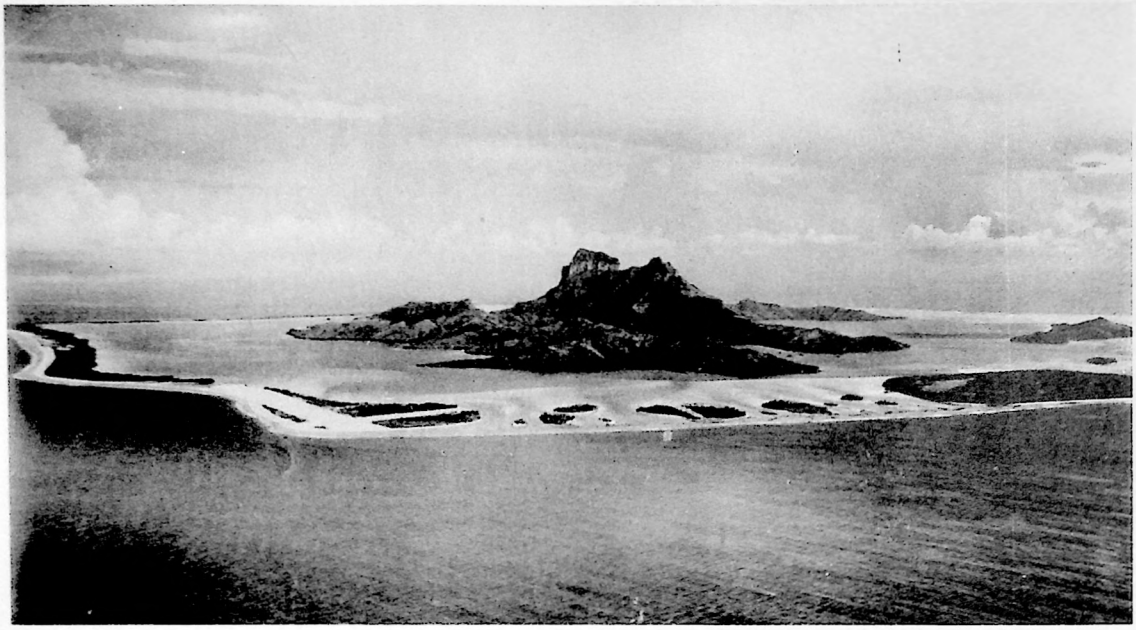


FIG. III–29. Aerial oblique photograph of a barrier coral reef.

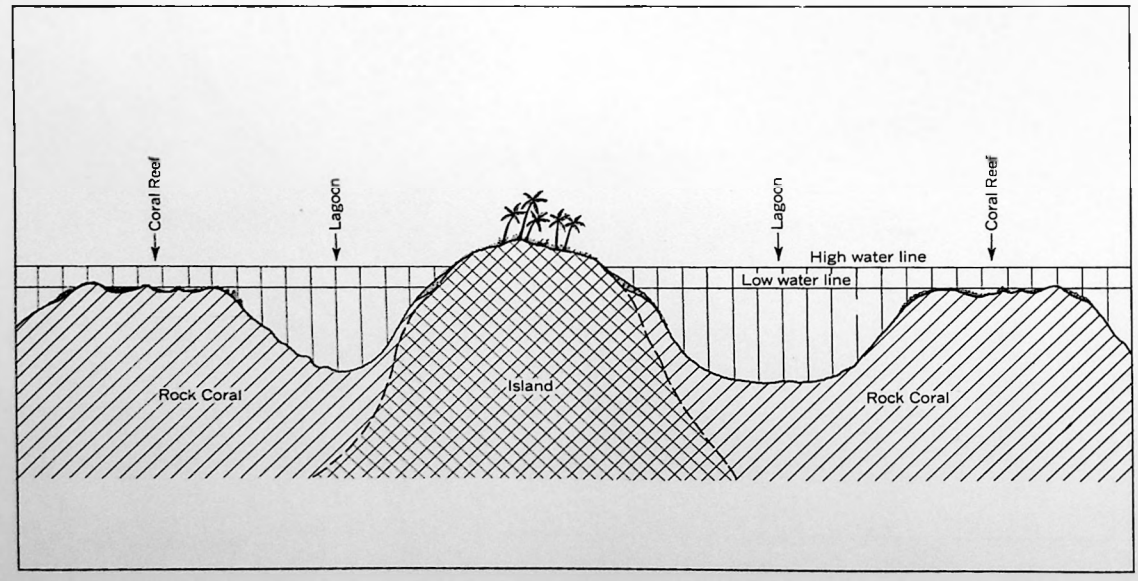


FIG. III-30. Diagrammatic profile of a barrier coral reef.

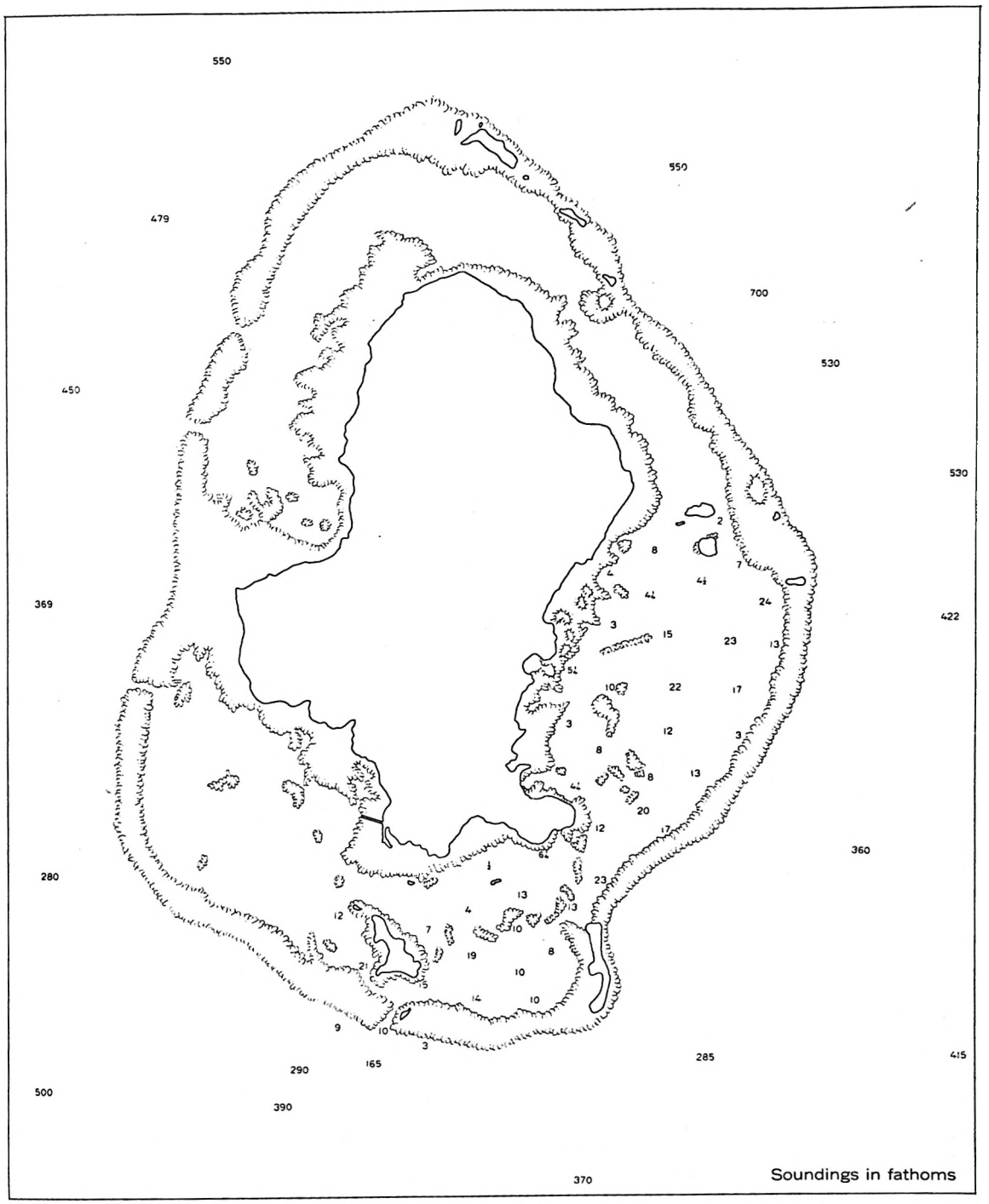


FIG. III-31. Chartlet showing a barrier coral reef combined with fringing reef.

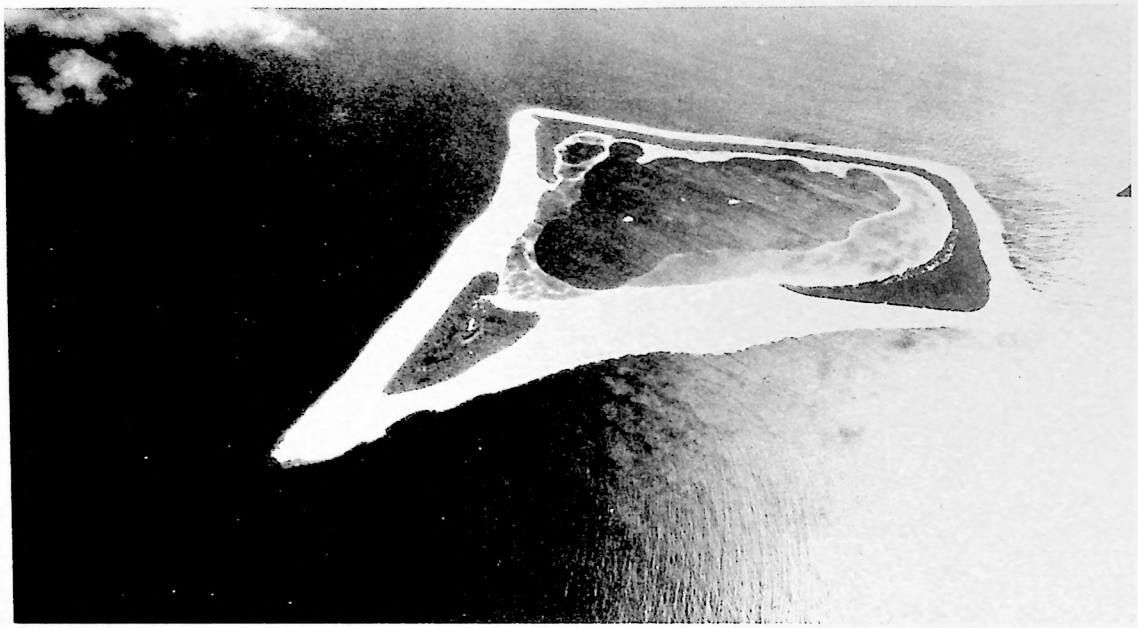


FIG. III-32. Aerial oblique photograph of a small atoll reef.

FIG. III-33. Aerial oblique photograph of a large atoll reef.

deep. Barrier reefs lie offshore and are separated from the land by a lagoon. The width of this type of reef will vary from a few hundred yards to a couple of miles. Some barrier reefs have small debris islands on them similar to atoll reefs. Fig. III-29 shows this type of reef. Fig. III-30 shows a cross-section view of a typical barrier reef and Fig. III-31 is a chartlet showing a typical barrier reef. It will be seen that the lagoon is quite shallow with numerous coral "pillars" while the water on the seaward side of the reef is very deep. Fig. III-32 shows a small atoll and Fig. III-33 shows a typical large atoll. An atoll reef is a barrier reef which encloses a lagoon. The reef is sometimes continuous but usually there are a few channels extending from ocean to lagoon. The lagoons are usually quite shallow, ranging in depth up to 200 or 300 feet. In the shallower parts, "pillars" of coral grow up from the lagoon floor, some of these may reach low tide level and form small reefs within the lagoon. The reefs are usually dotted with small islands, which are nothing more than accumulated debris from the reef itself. After the islands have built up above high water and become fairly permanent, floating seeds and vegetation will take root and start a vegetative cover that eventually stabilizes the reef-island. These reef-islands are usually surrounded by a beach 10 to 50 feet or more wide. The beach is commonly coral sand, shell fragments, and other organic debris. Fig. III-34 shows a cross-section view of a typical atoll reef and Fig. III-35 is a chartlet of a typical large coral atoll reef. It will be seen that the water inside the lagoon is comparatively shallow and has numerous coral "pillars". The water on the seaward side of the reef is very deep.

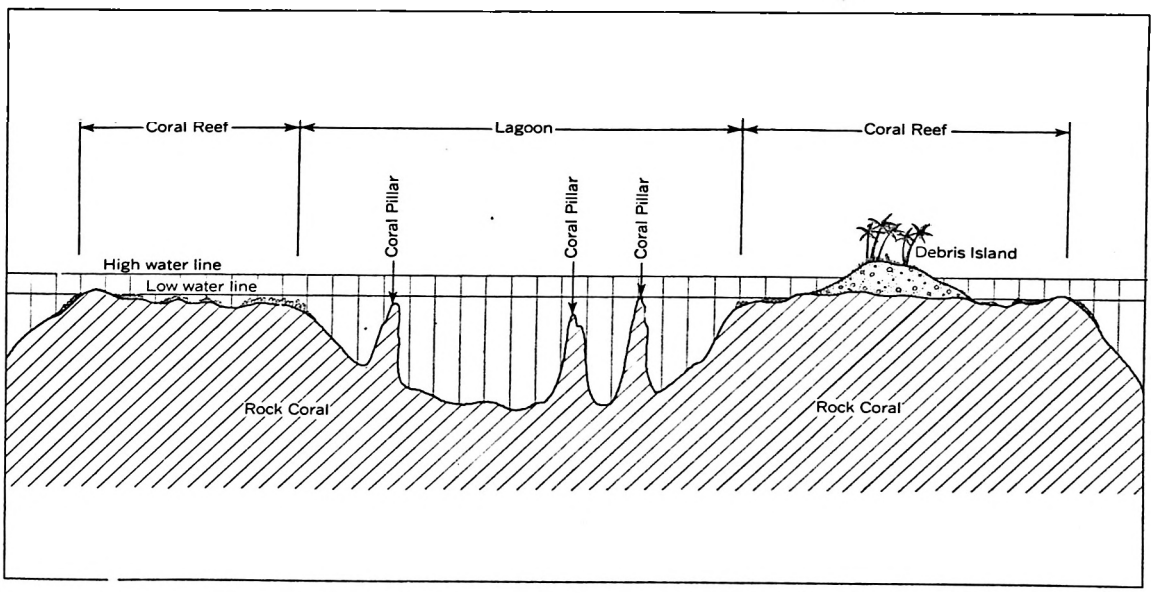


FIG. III-34. Diagrammatic profile of an atoll reef.

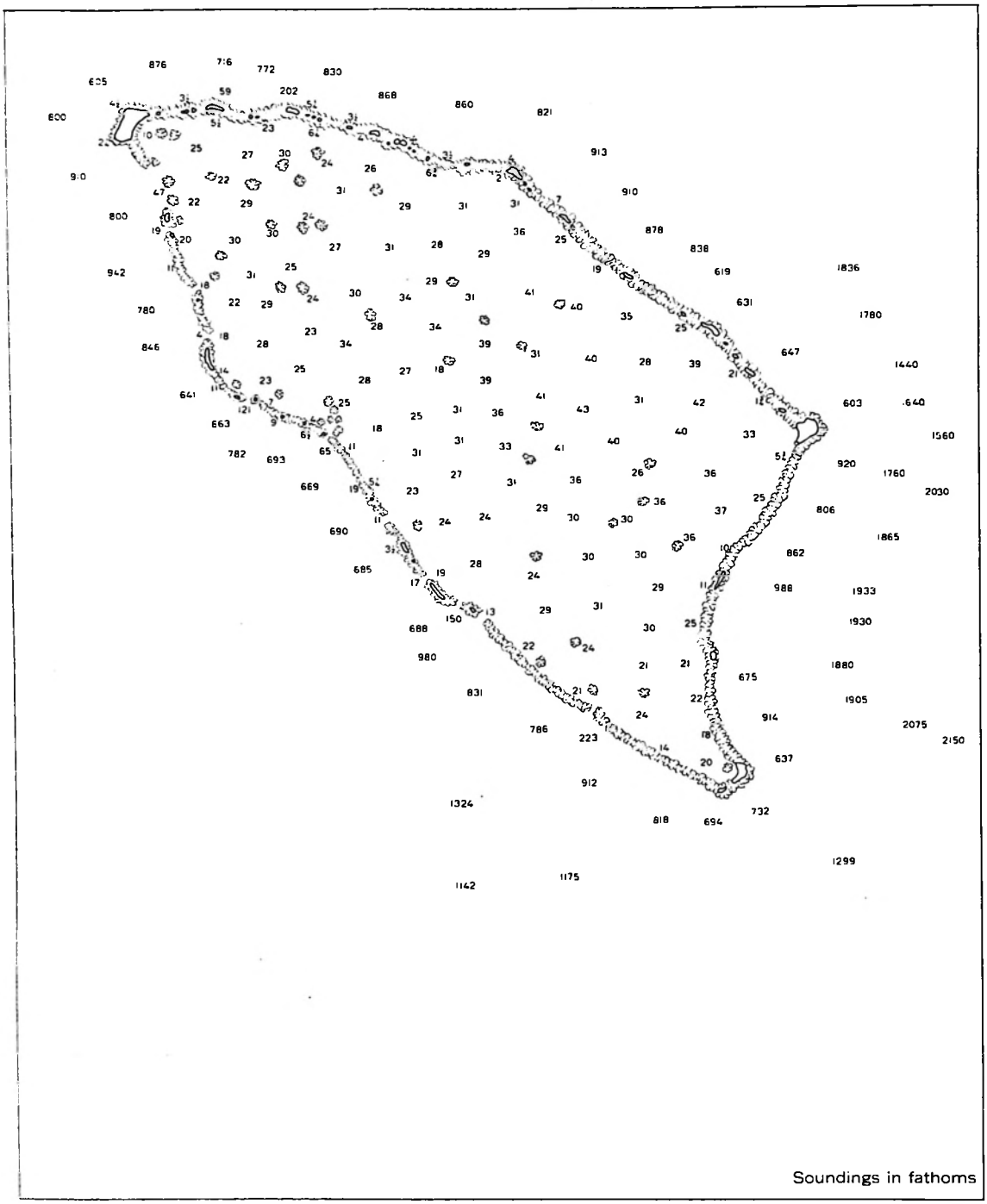


FIG. III-35. Chartlet of a typical large coral atoll reef. Note the numerous coral "pillars" inside the lagoon and the extreme deep water just off the outside edge of the reef.

The following points should be remembered relative to coral reefs:

1. Coral formations are not ordinarily found in latitudes higher than 30° or opposite the mouths of muddy or fresh water streams.

2. Generally the water on the ocean side of the reef is very deep and the reef drops off quite rapidly on the ocean side.

3. Corals cannot stand exposure to the air for more than a few hours. Consequently coral cannot extend its upward growth higher than the line of mean low water.

4. Actual depths of coral "pillars" and submerged reefs which were photographed under ideal conditions are very hard to determine on small scale photographs.

5. Generally a "lip" exists along the seaward edge of all coral reefs. The existance of this "lip" is dangerous for boats crossing the reef especially when the water is near low tide.

(b) Deltas:— In this manual, the term "delta" is used to indicate river deltas as well as alluvial plains and outwash plains. Delta shorelines are formed by deposits of alluvium in the sea and resemble in many respects the emergent shoreline.

River deltas result from deposition of sand, mud, and gravel at river mouths. The deltas are of two general types, those that are formed in protected bays, and those that are formed along the more or less unprotected coasts of the world. The bays were probably originally formed by a partial submergence of old river valleys. The rivers carry much sediment to these bays or to the sea, and when the flow of water spreads out on emptying into the wide expanse of open water, it slows in speed and the sediment which was in traction settles to the bottom. This sand, mud, and gravel, called "flood plains", gradually spreads and eventually fills the entire bay. At the same time the main river, at the head of the old bay, branches out into many channels cutting passage ways through the deposited debris. In many delta areas of the world the accumulation of mud and sand, called tidal flats, is subject to tidal inundation, from small areas up to those of many square miles. Some deltas are covered with a dense growth of mangrove and others are areas of mud flats that will dry at low tide. In either case, this type of delta is extremely difficult for the photogrammetrist to delineate, because in most cases the sediment suspended in the river water will, on reaching the bay or sea, cause a large expanse of discolored water. Such a murky patch of water makes it very difficult to determine on an aerial photograph the dangers to navigation, or the boundary between the offshore and foreshore area. Figures III-36, III-37 and III-38 are typical examples of the more or less protected river deltas. Fig. III-39 is a chartlet of a typical river delta. It can be seen from the photographs and the chartlet that the water around the protected river deltas is very shallow with numerous submerged mud banks. In the tropics the mud areas are usually covered with mangrove which add to the difficulties of delineation.

The deltas that form along the more or less unprotected coasts of the world have been subdivided by D.W. Johnson into three main types, namely: lobate, cuspate, and arcuate. First a submerged river mouth bar is formed and, if the sediment suspended in the river water is great enough and if the wave and current action of the sea is favorable the

FIG. III–36. Aerial oblique photograph of a typical river delta. Note the mangrove growing on the deposited mud.

FIG. III–37. Aerial oblique photograph of another typical river delta. Note the mud flats and young mangrove starting to grow along the streams.

FIG. III-38. Aerial oblique photograph of another typical river delta. Note the mud flats and submerged bars.

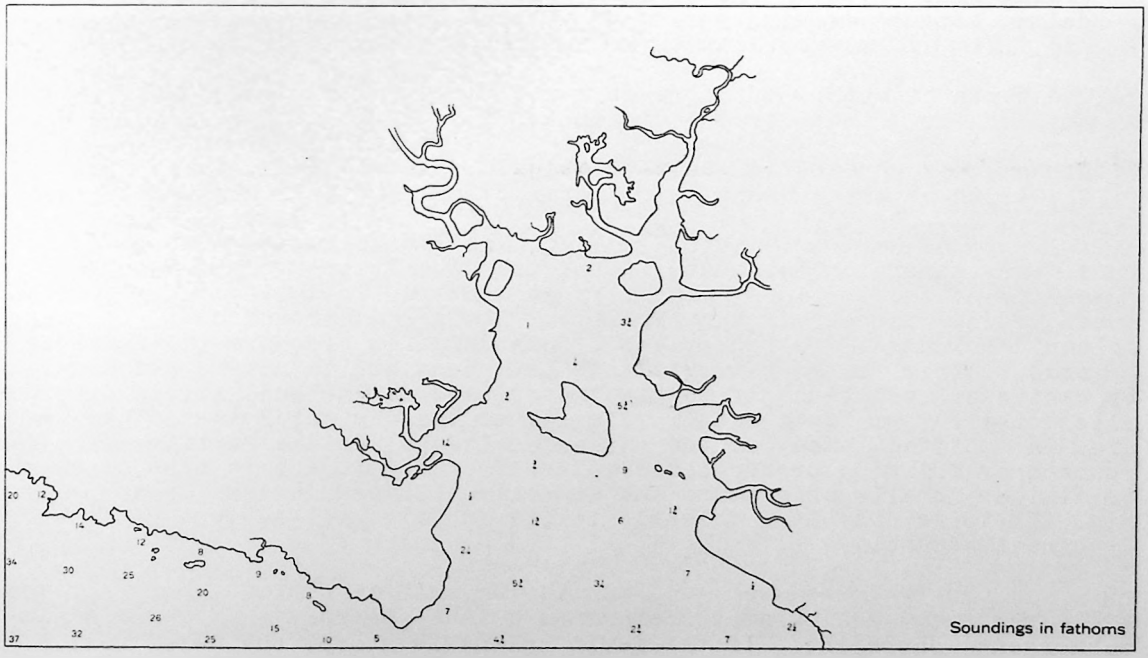


FIG. III-39. Chartlet of a typical river delta. Note the shallow water.

river mouth bar is replaced by an extensive delta. The forms that the different deltas assume are due both to the streams which produce them and to the waves and currents which later modify them. These types are illustrated in Figures III-40, and III-41 and III-42 respectively. Fig. III-43 is a chartlet of the Mississippi River delta which is a famous large lobate delta. Fig. III-44 is a chartlet of a small cuspate delta in Central America while Fig. III-45 is a chartlet of a small arcuate delta in Borneo. It will be noted that the water is fairly deep just off these delta areas.

Alluvial plain shoreline results from the uninterrupted processes of normal erosion and is formed where the broad alluvial slope at the base of a mountain range is built forward into the sea. This type of coastal feature is similar in many respects to the emergent coastal plain. This is particularly true near the foreshore zone. The offshore zone would normally be steeper, similar to the frontal slope of a river delta. Fig. III-46 illustrates the alluvial plain shoreline.

The outwash plain shoreline is very similar, in many respects, to river deltas and alluvial plains. Streams emerging from melting glaciers carry gravel, sand, and silt which are deposited into the sea forming a delta. The outwash plain shoreline is illustrated in Fig. III-47.

From the preceding discussion relative to river deltas, alluvial plains, and outwash plains and from a study of the different illustrations, the following points should be remembered:

1. It is very difficult to delineate on an aerial photograph the intricate detail, dangers to navigation, underwater features, and the dividing line between the offshore and foreshore areas that make a delta, because of expanses of discolored water and extensive areas of mud flats and mangroves with meandering streams and rivulets.

2. The depth of water offshore of a protected river delta may be quite shallow for a considerable distance.

3. Along the unprotected deltas, alluvial plains, and outwash plains, the depth of water drops quite rapidly near the offshore zone.

(c) *Volcanic Shorelines:*— Volcanic shorelines are, as a general rule, very simple to delineate. They are usually small circular islands (speaking of the volcanos generally encountered in delineating coastal areas) found largely in the Pacific. The water around most of these volcanic islands is very deep and offers very few offshore navigational hazards. After the volcanic islands have been built upward and outward by continued additions of ejected materials, marine and stream erosion alter their form in a manner similar to that by which any other land area is modified. Many of the volcanic islands in the Pacific are surrounded by fringing or barrier coral reefs. Therefore, this type of coast is similar in all respects to the shorelines covered under coral reefs. Fig. III-48 is a typical volcanic island and Fig. III-49 is a profile of a volcanic coast.

(d) *Fault Shorelines:*— It is very difficult for anyone, except the experienced geologist, to determine a fault shoreline from the mature submergent shoreline. If the fault plane is steep, the water near the shore is usually very deep and the wave erosion is very slight. For all practical purposes, the fault shoreline will be treated by the photo-

FIG. III–40. Aerial oblique photograph of a lobate delta.

FIG. III–41. Aerial oblique photograph of a cuspate delta.

FIG. III–42. Aerial oblique photograph of an arcuate delta.

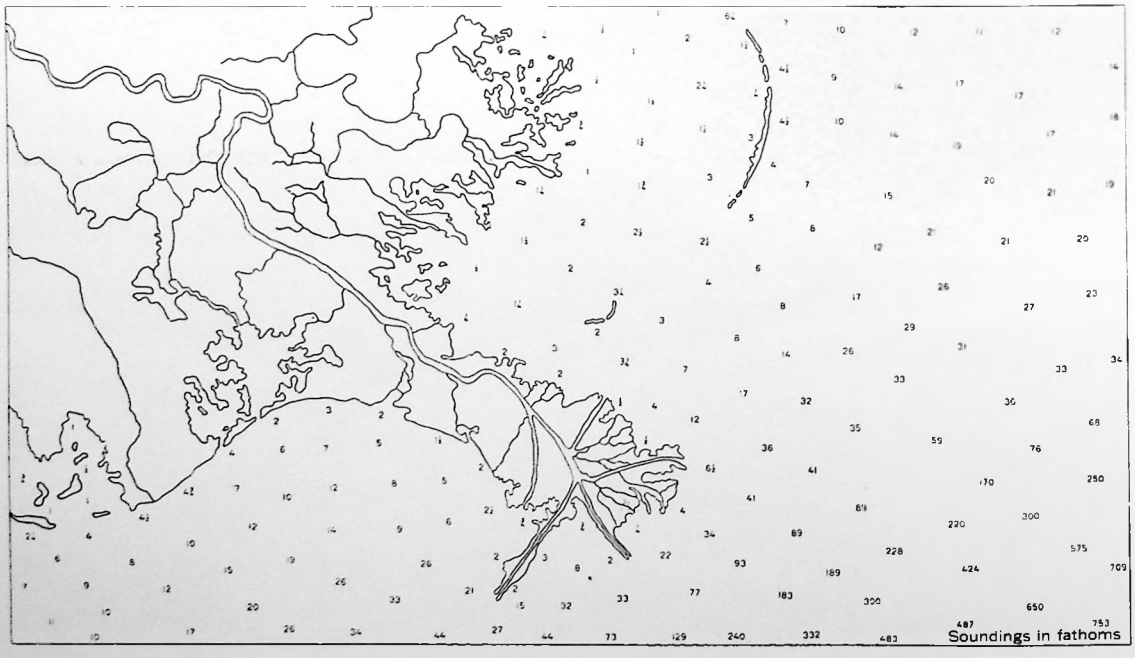


FIG. III-43. Chartlet of the Mississippi River delta. This is a famous large lobate delta.

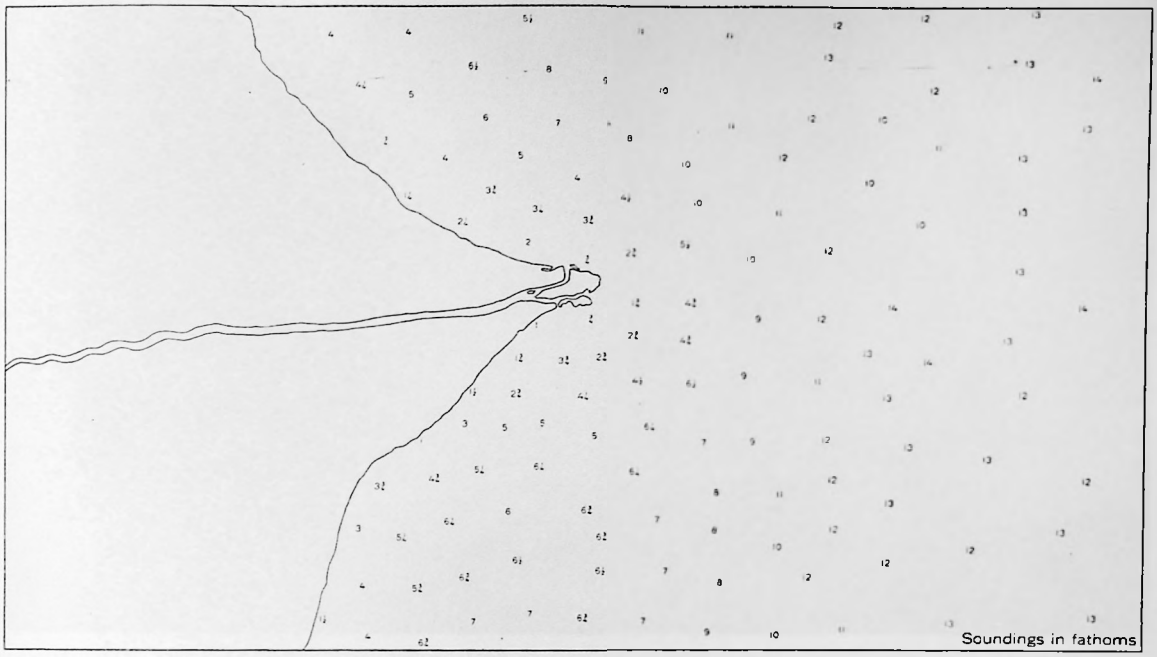


FIG. III-44. Chartlet of a small cuspate delta in Central America.

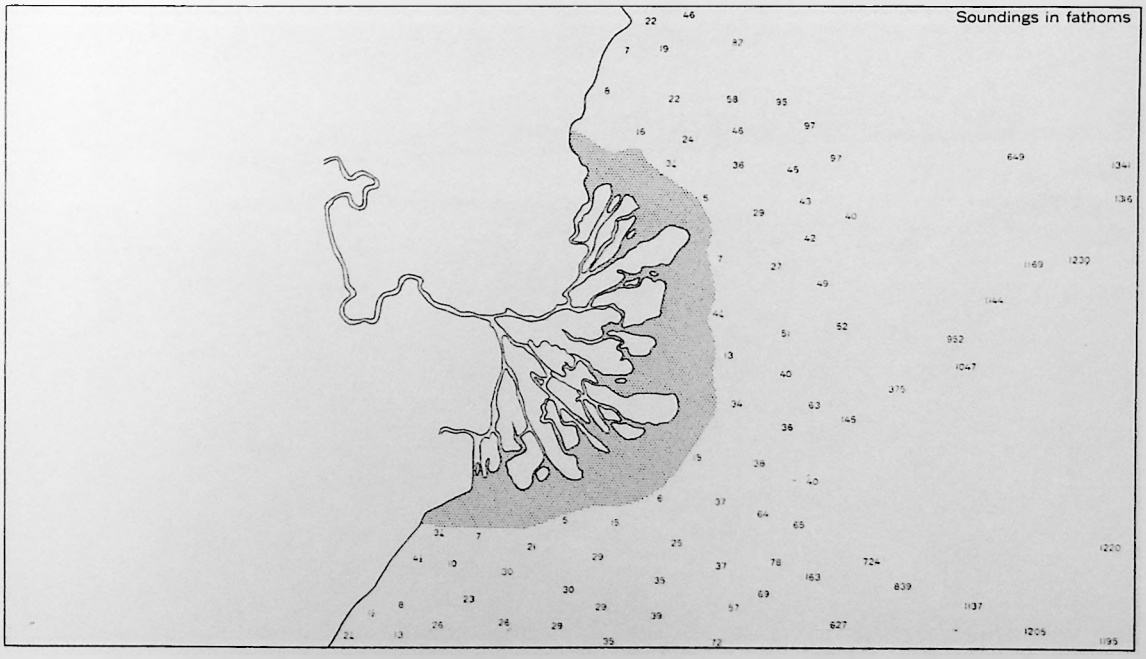


FIG. III-45. Chartlet of a small arcuate delta in Borneo.

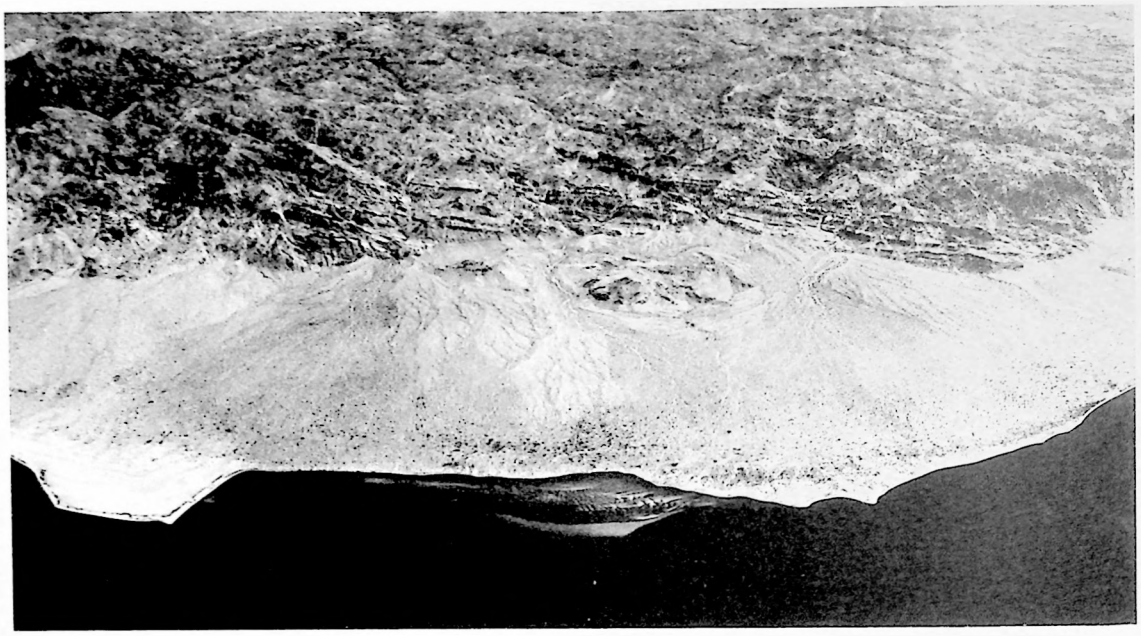


FIG. III–46. Aerial oblique photograph of an alluvial plain.

FIG. III–47. Aerial oblique photograph of an outwash plain.

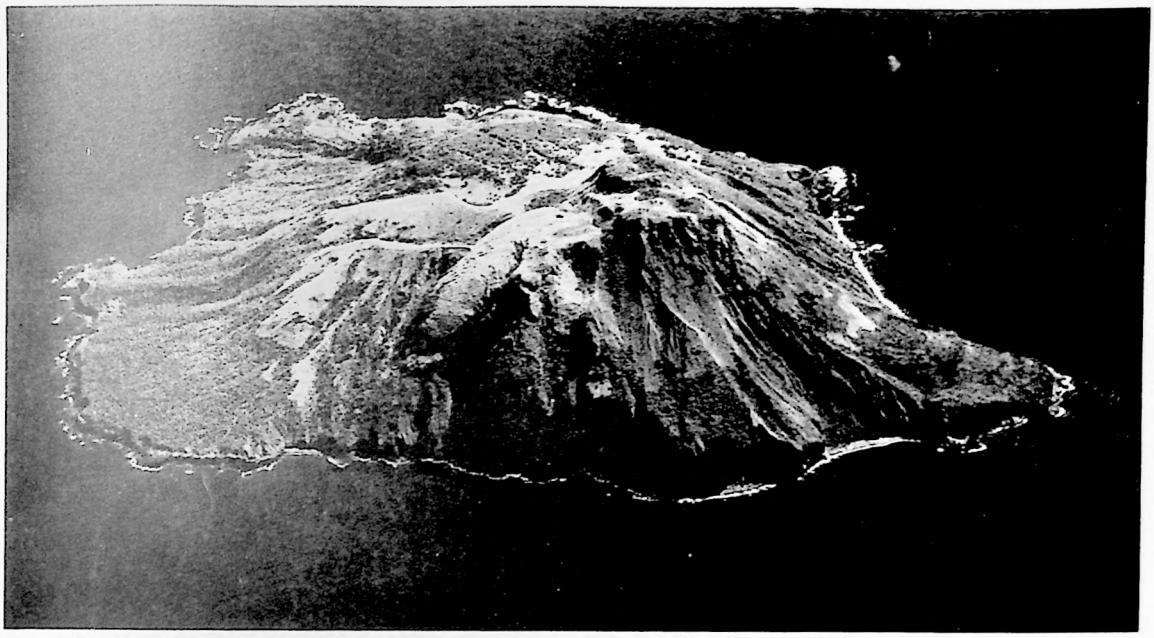


FIG. III–48. Aerial oblique photograph of a typical volcanic island. Note the new lava flow into the sea.

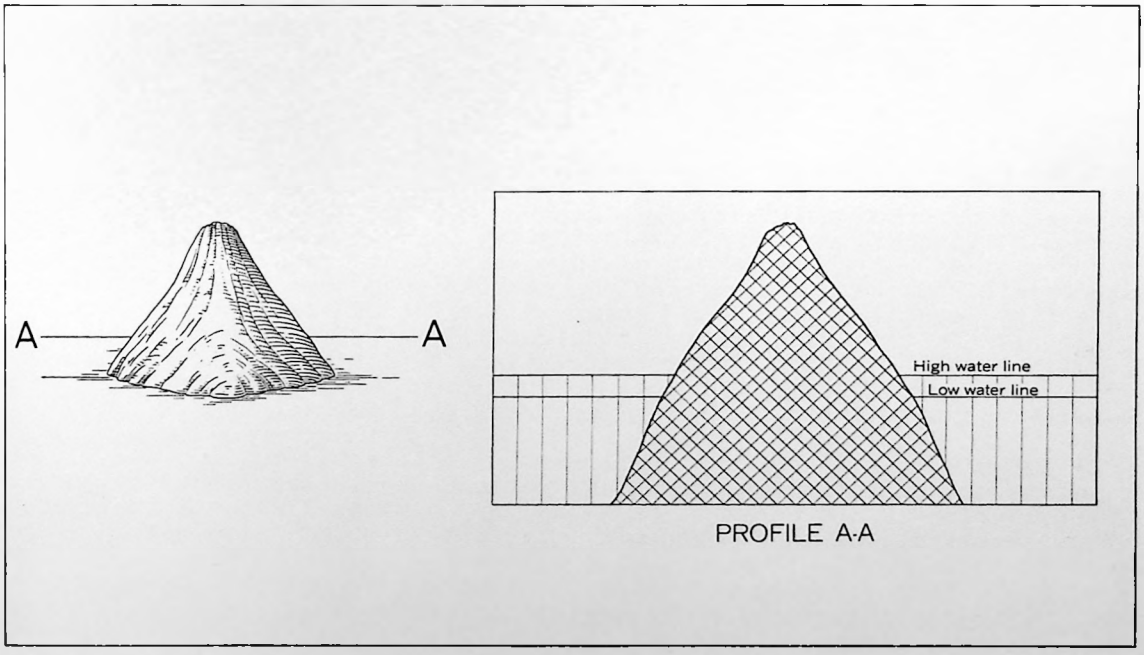


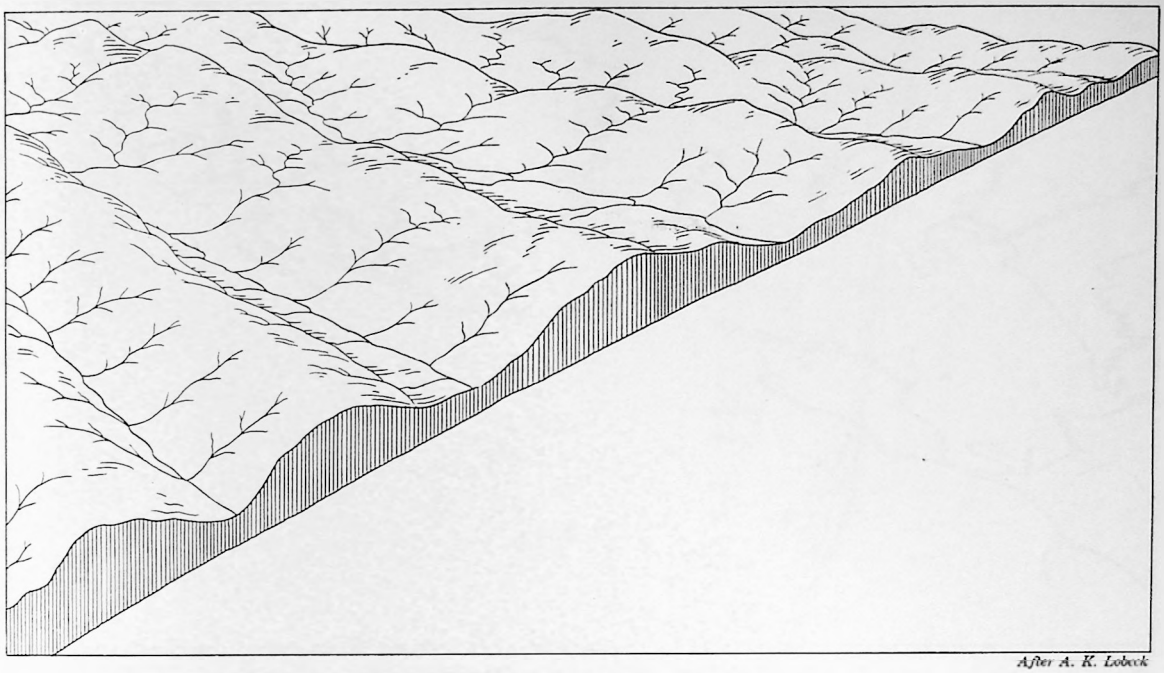
FIG. III-49. Diagrammatic profile of a volcanic island.

grammetrist the same as a mature submergent shoreline. A typical example of a fault shoreline is shown in Fig. III-50, and Fig. III-51 is an oblique aerial photograph of a shore fault that has become a fault shoreline.

IV. COMPOUND TYPE :— Compound coasts are the result of two or more of the three processes previously discussed. Several variations may have taken place in recent geologic time, recent enough for their influences to remain marked on the present coast. Actually, it is of very little importance whether the coast has emerged then submerged or vice versa - the main interest is in being able to recognize the type that has the greatest influence on the coast that is being delineated. The main reason for discussing this type of coast in this manual is to possibly avoid some confusion. For example, one may encounter a coastal area, the shorelines of which exhibit the irregular pattern of the submergent type in combination with an offshore bar. What has probably taken place in such a case is that extensive emergence occurred first, followed by a slight submergence that has drowned the valleys carved in the emergence stage. Fig. III-52 is a diagrammatic illustration of an emergent type coast followed by submergence, and Fig. III-53 is an aerial oblique photograph of an emergent type coast followed by a slight submergence. Fig. III-54 is a chartlet of a typical coast of this type. It will be seen from the photograph and the chartlet that beyond the bar the sea bottom profile has the same characteristics of the emergent coast. The first stages of the processes further developing this type of shore profile will be similar to the stages developing the emergent type; that is, the offshore bar will be shoved back against the mainland until a mature shore profile is developed, in which case the waves are able to attack the headlands. The further development of the shore profile from this stage on will be similar to that of the submergent type.

Where submergence occurs first, followed soon after by partial emergence, the essential characteristics of the coast would be little affected by the emergence and would merely reduce the amount of the original submergence. Therefore, the processes of further developing the shore profile would be similar to submergence, except the process would be greatly simplified. Fig. III-55 is a diagramatic illustration of a submergent type coast followed by a slight emergence, and Fig. III-56 is an aerial oblique photograph illustrating the same condition. Fig. III-57 is a chartlet of a typical coast of this type. It will be seen from the photograph and the chartlet that the terrain is rather hilly surrounded by a flat coastal plain. The water adjacent to an area of this type is likely to be quite shallow with considerable mud flats and submerged mud or sand bars. If, on the other hand, a long geologic time interval existed between the former submergence and the subsequent emergence, the coast would be similar, in all respects to the emergent type.

RESUME:— It is believed desirable at this point to stop and give a brief resume of the processes briefly discussed in the preceding pages. The evolution of the world's coasts is very interesting, but it is also very involved. It is unfortunate that only a brief discussion can be made in this manual. The evolution of coastal areas is not only interesting, but to the photogrammetrist, it is highly important as such knowledge will aid in the proper interpretation of coastal features. It is therefore recommended that all persons - cartographers, hydrographers and photogrammetrists- who are working along coastal areas become familiar with the processes developing the different shore profiles. There



After A. K. Lobeck

FIG. III-50. Diagram illustrating a fault shoreline.

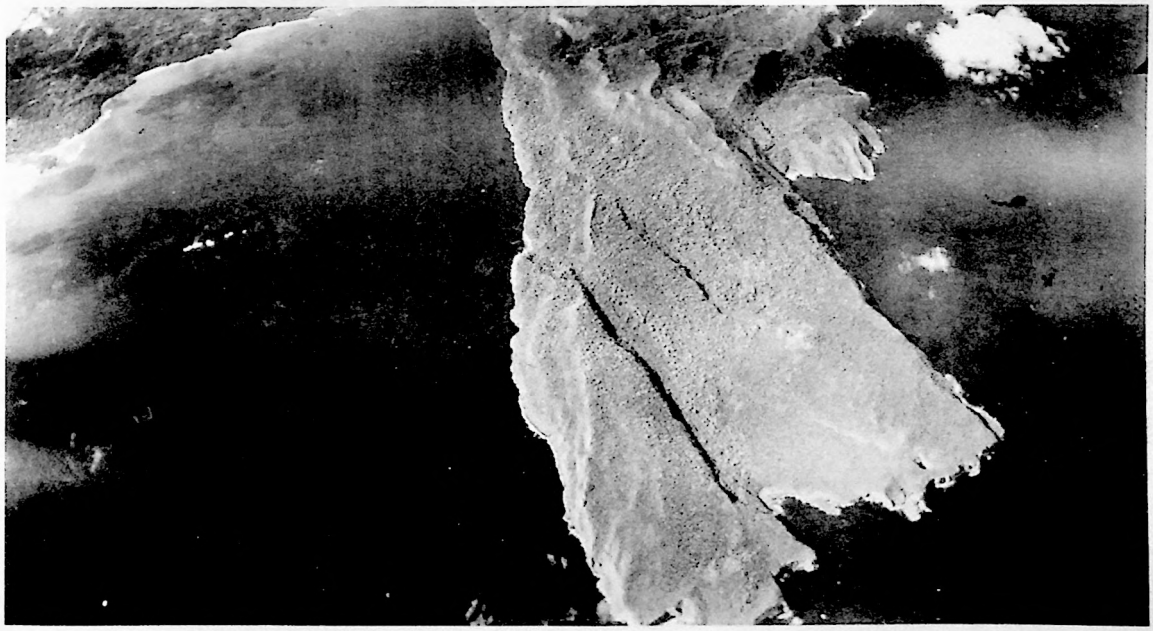


FIG. III-51. Aerial oblique photograph of a fault shoreline.

FIG. III-52. Diagram illustrating a compound coast—emergence followed by submergence.

FIG. III-53. Aerial oblique photograph of a compound coast–emergence followed by a slight submergence.

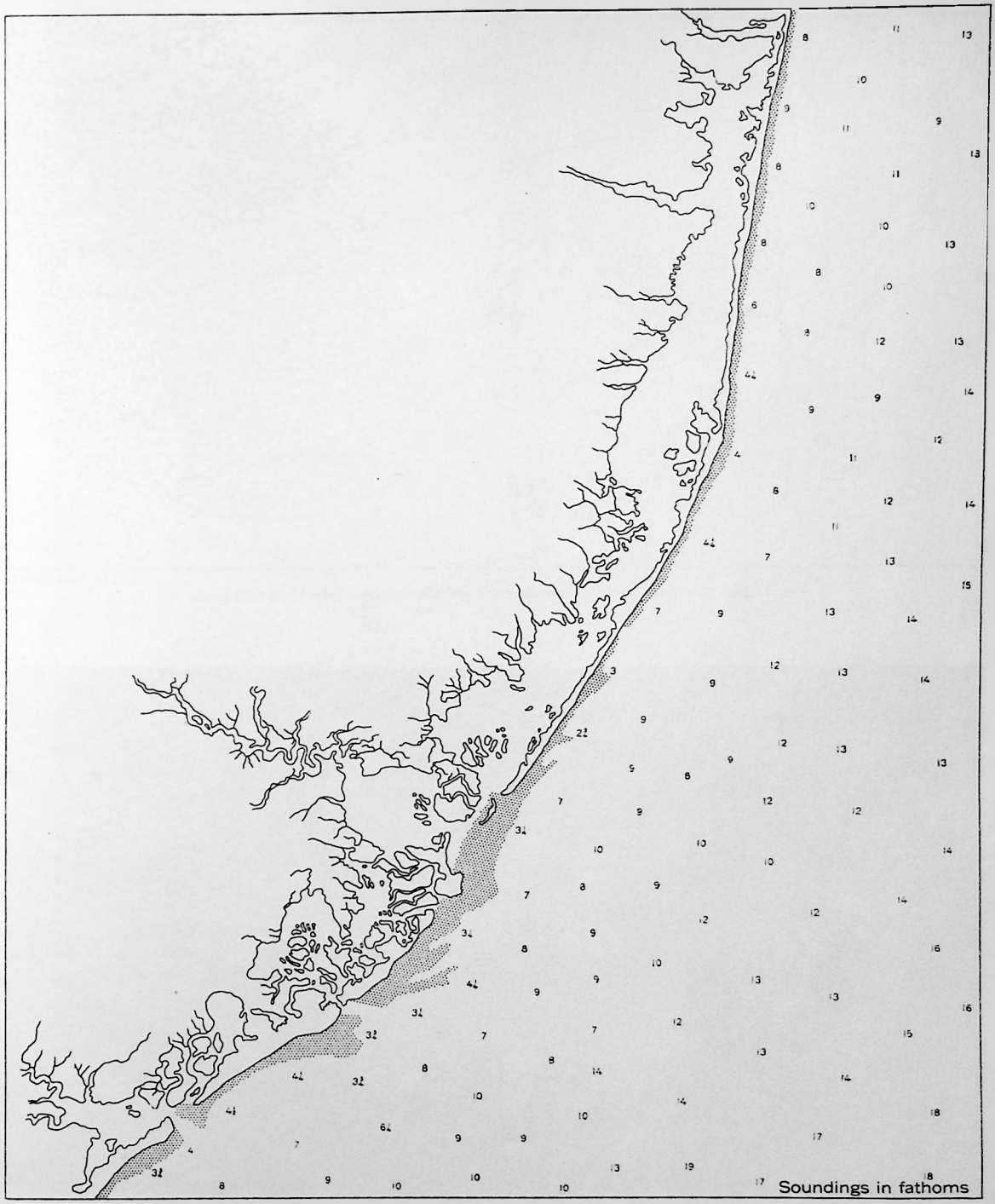
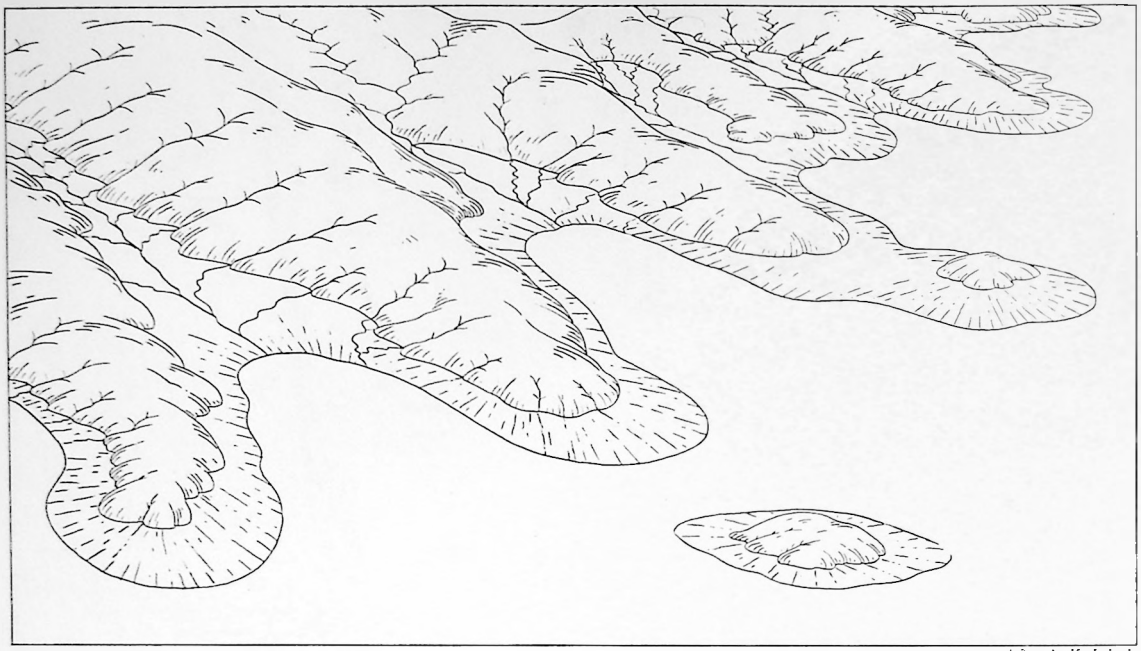


FIG. III-54. Chartlet of a typical coast where emergence first occurred followed by a slight submergence.



After A. K. Lobeck

FIG. III-55. Diagram illustrating a compound coast—submergence followed by emergence.

FIG. III-56. Aerial oblique photograph of a compound coast—submergence followed by a slight emergence.

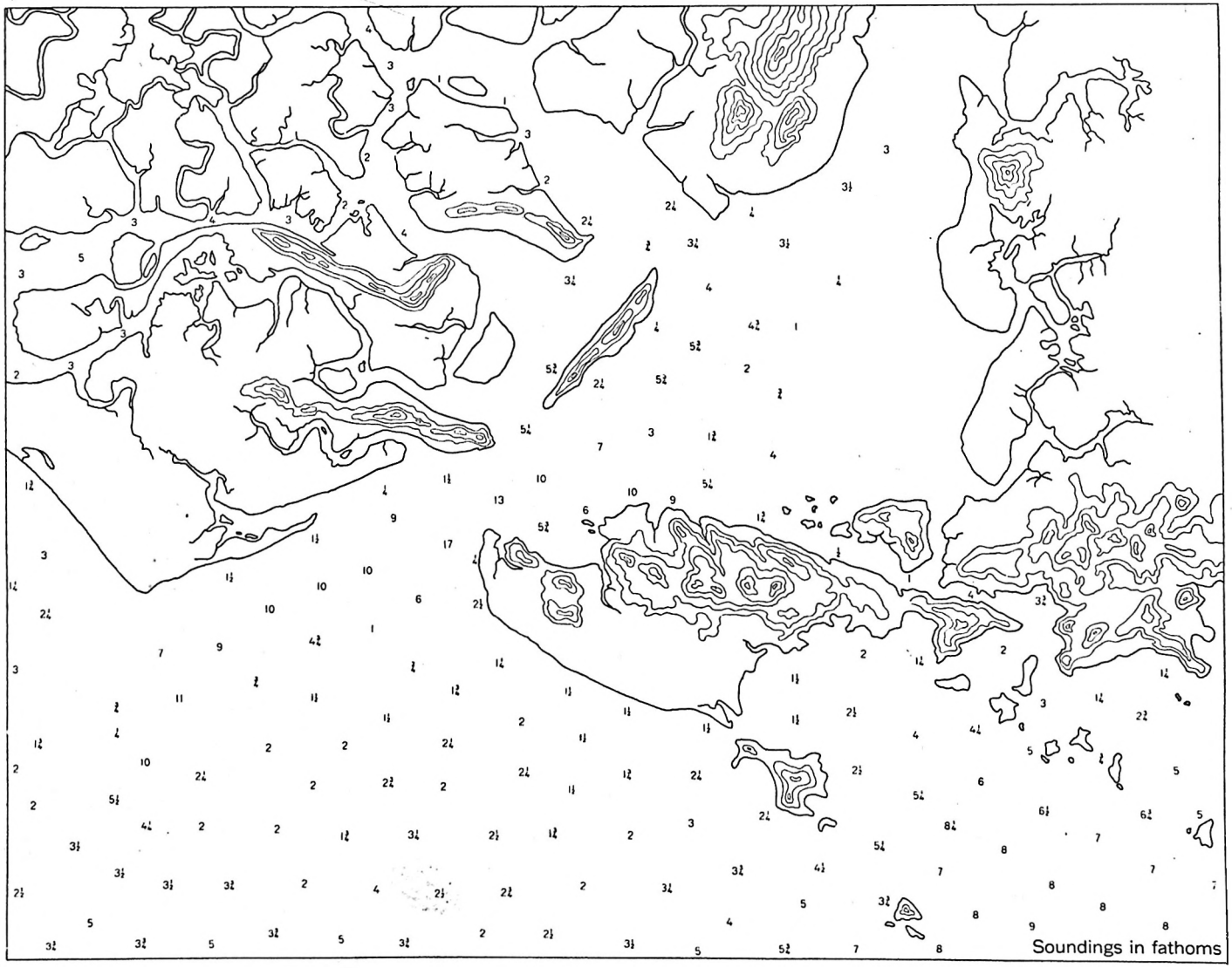


FIG. III-57. Chartlet of a typical coast where submergence first occurred followed by a slight emergence.

are a number of excellent books on the subject which may be found in any good library.

The writer has briefly traced the history of the most important shore profiles and it was noted that where partial submergence occurred, the result was a coast of bays and headlands; that where emergence occurred, the coast was fairly straight with few, if any, indentations although, in the initial stage, the water will normally be quite shallow for considerable distance offshore; that neutral coasts are formed by (1) the deposit of sand, gravel, and mud into the sea by the action of rivers and glaciers, (2) by marine organisms that build coral reefs, and (3) by volcanic action, and, lastly, it was noted that compound coasts are formed by a combination of two or more of the above processes. In any and all cases, the subsequent action of the sea on all types of coast is toward the production of a shoreline more or less regular. On an irregular coast, cliffs form at the headlands while debris is deposited in the bayheads, and therefore, all factors are jointly contributing to the process of straightening the coast. It must be understood that both rapid and intermittent changes occur in the processes changing a coast. The rate and amount of erosion are determined largely by the nature and arrangement of the geological formations and whether the coast is protected by its orientation with respect to wave and current energy available for destructive action or shortages of cutting tools with which to erode. Some coasts of the world have been little affected by erosion, for they are formed of resistant hard igneous and metamorphic rocks while other coasts of the world are of less resistant rock formations (usually sedimentary rocks) and erosion in these areas has resulted in the formation of long stretches of regular coasts. In still other parts of the world, the coasts consist of clay, gravel, and sand of the glacial drifts. These coasts are incapable of seriously resisting wave attack, with the result that the rate of erosion is very rapid.

The amount of change, after maturity has been reached, for all types of coasts, will depend largely on the condition of stability or on the condition of balance between erosion, weathering, and the ability of the waves to transport the debris accumulating in front of the shoreline. There are five general types of erosive conditions that cause changes in coasts, namely: (1) subaerial erosion or the erosion that may take place high above the shoreline by wind, running water, frost, and glacial action; (2) erosion due to characteristics of the geological structure as is the case of coastal areas where alternate strata of gravel, sand and clay are dipped toward the sea. The water may lubricate the clay layer causing the seaward slipping of the strata above the clay layer; (3) marine erosion, or the erosion due to waves assisted by tides and currents; (4) organic erosion, or the erosion due to rock-boring organisms working below water level on some parts of a coast; (5) erosion caused by man, in some cases due to a lack of understanding of the fundamental principles of erosion factors such as removing the material (sand and gravel from along the shore) that is actually protecting the shore from wave erosion.

In passing, it is believed advisable to briefly discuss a few of the many minor shore features, such as: tombolos, spits, bars and beach cusps. Persons reading this who are interested in studying aerial photographs for making extremely large scale amphibious charts may not agree that these features should be classified as minor features, or may wonder why beach ridges, ripple marks, etc., are not thoroughly discussed here. It should be pointed out what this manual is for use by photogrammetrists and cartographers compiling information for ordinary small scale (small

scale in comparison with large scale beach information for amphibious operations) navigational charts and cannot show some of this information. Therefore, considering the purpose for which this manual is intended, these items are minor shore features.

Spits are long fingers of accumulated debris (sand, gravel, and mud) jutting out from land. All of the debris that is eroded from the headlands is not carried out to sea; some of it is deposited either inside the bays to form bayhead bars, or midbay bars; while a quantity of the debris is deposited at the bay entrance to form baymouth spits. The actual formation of these spits and bars is not of too much importance. However, if the debris deposited is of long duration, the spit will continue to build and, due to tidal currents, longshore currents, and wave action, will assume many varied shapes of compound and complex nature with one or many hooks. At other places, a spit will build across a mouth of a bay forming a baymouth bar. A tombolo is an island connected to the mainland with one or more bars, and a complex tombolo is where several islands are united with each other and with the mainland by a series of bars.

Beach cusps are triangular shaped deposits of sand, gravel and other debris regularly spaced along a beach. The apex of the triangle points toward the water and the distance between the apexes will vary from a few feet, in protected coves, to as much as one hundred feet in the more exposed areas. Figures III-58 thru III-67 are typical examples of these minor shore features. Splendid examples of compound spits are shown on the small chartlets of Sandy Hook and Cape Cod, Figures III-68 and III-69.

V. VEGETATIVE TYPE:— Vegetation along a coast sometimes makes it very difficult to delineate the proper shoreline. This is particularly true in areas of extensive mangrove growth. Only the tropical vegetative type growing along the sea coast will be discussed in this manual. As a general rule, vegetation of the temperate and frigid zones do not interfere with the shoreline delineation. Information for the following discussion on vegetative types is taken from the U.S. Navy Photographic Intelligence Center Report No. 7, "Pacific Landforms and Vegetation". This report is recommended to anyone interested in vegetation coverage for both the tropical and temperate zones of the Pacific.

(*a*) *Nipa Palm:*— This palm is not in tree form. The leaves are 10 to 15 feet long and form a uniform stand with a height about the same as the length of the leaves. The leaves are light in tone and rarely in distinct rosettes. The nipa palm is not to be confused with sago palm the leaves of which are dark in tone forming a distinct rosette. The nipa palm is distributed at sea level in areas that are usually submerged at high tide. They usually grow in such dense stands that few, if any, other plants can grow in association with them. They are usually found as a fringe along tidal streams. They are less tolerant to salt water than mangrove, but in general are limited to brackish waters often upstream and adjacent to mangrove. Fig. III-70 is a stereo-pair of photographs on which is shown nipa palm.

Important points to remember about the nipa palm:

1. It is generally recognizable on aerial photographs by its feathery appearance, light tone, uniform height, and swampy location.

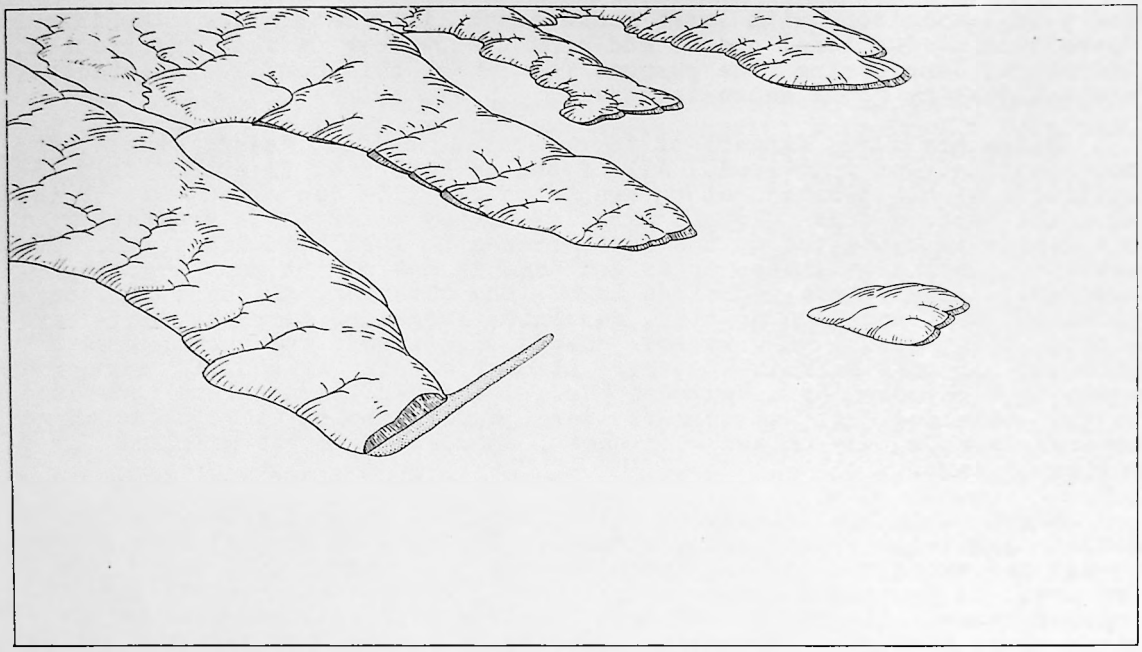


FIG. III-58. Diagram illustrating a simple spit.

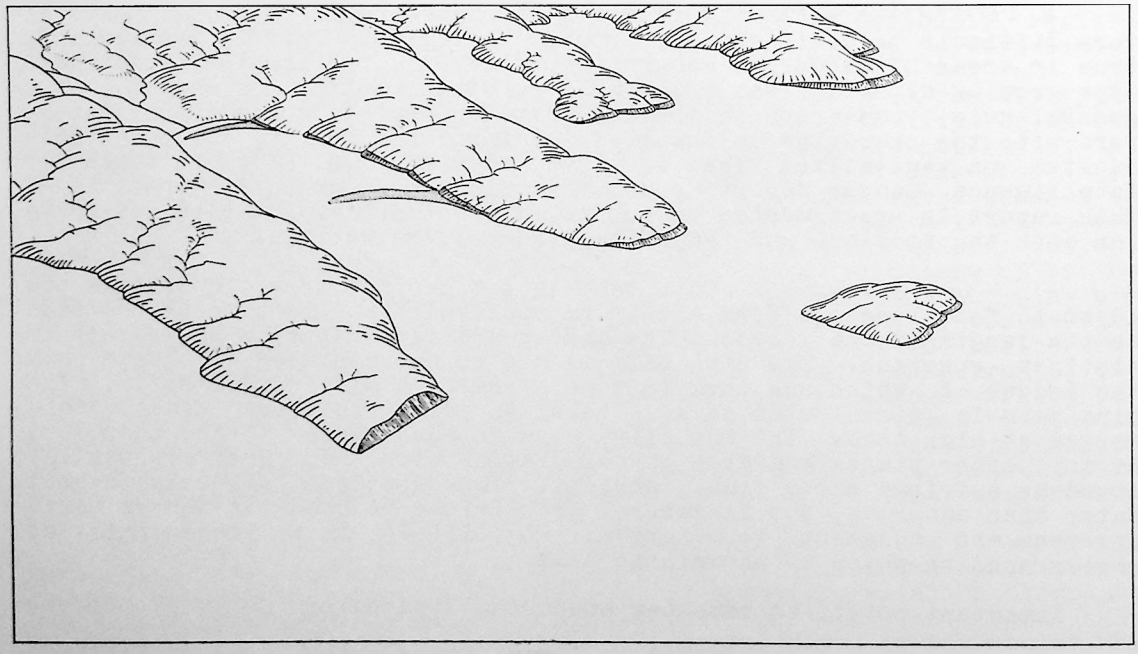


FIG. III-59. Diagram illustrating a bayhead bar and midbay bar.

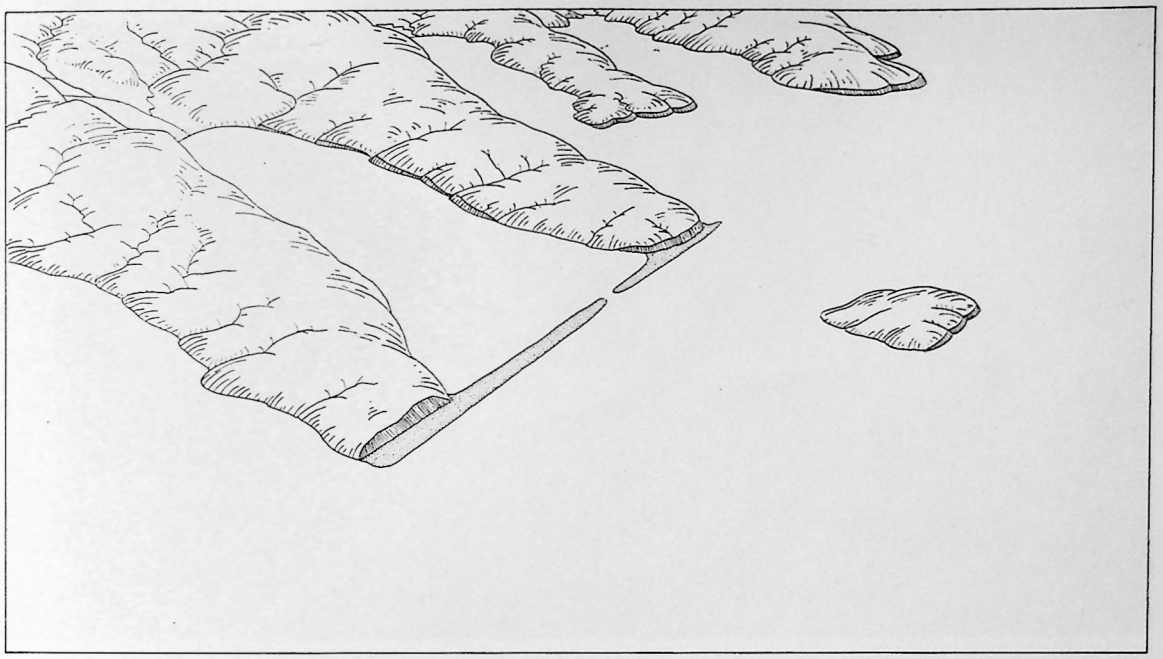


FIG. III-60. Diagram illustrating a baymouth bar.

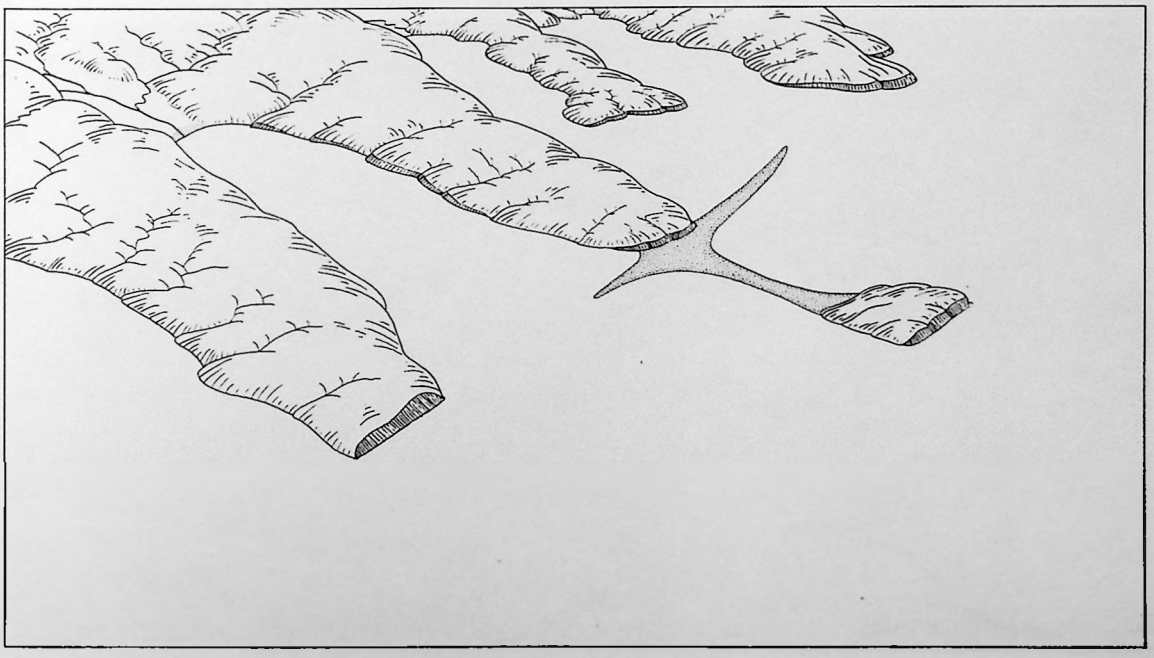


FIG. III-61. Diagram of a simple tombolo.

FIG. III-62. Diagram of a complex tombolo.

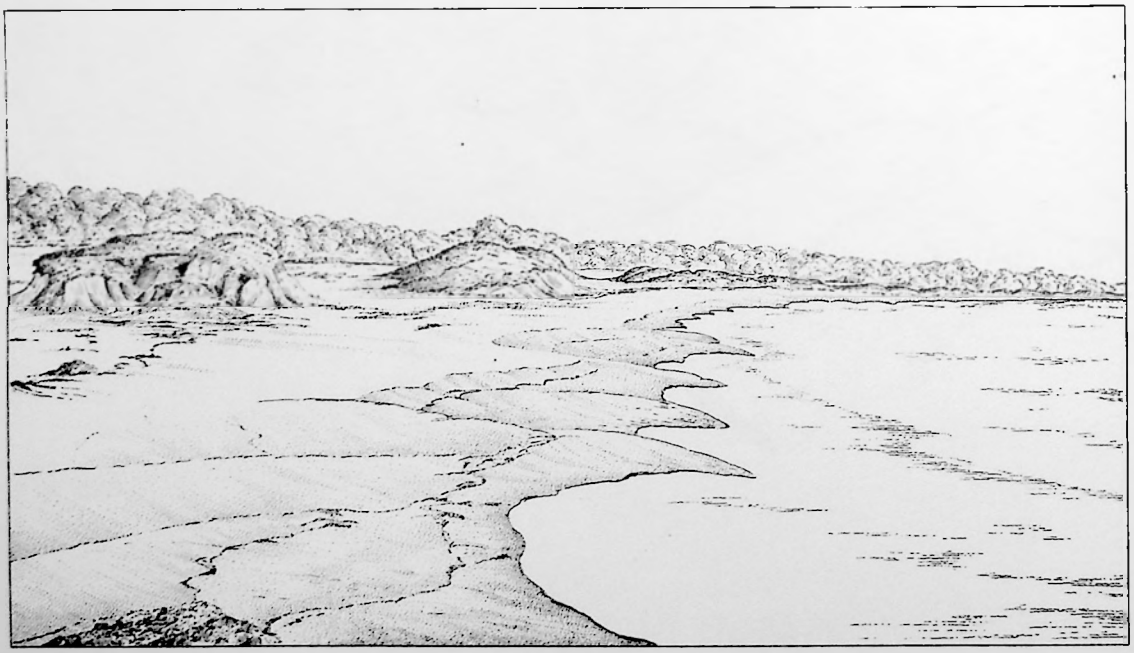


FIG. III-63. Diagram illustrating beach cusps.

FIG. III–64. Aerial oblique photograph of a simple tombolo.

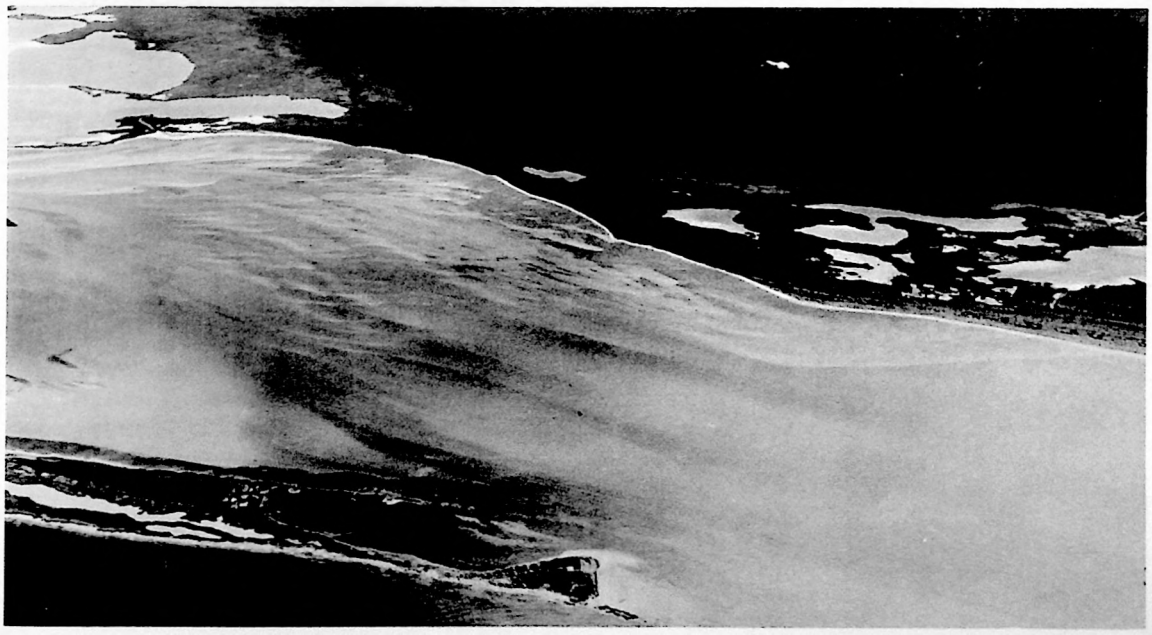


FIG. III–65. Aerial oblique photograph showing different bar formations within a bay.

FIG. III–66. Aerial oblique photograph of a compound spit.

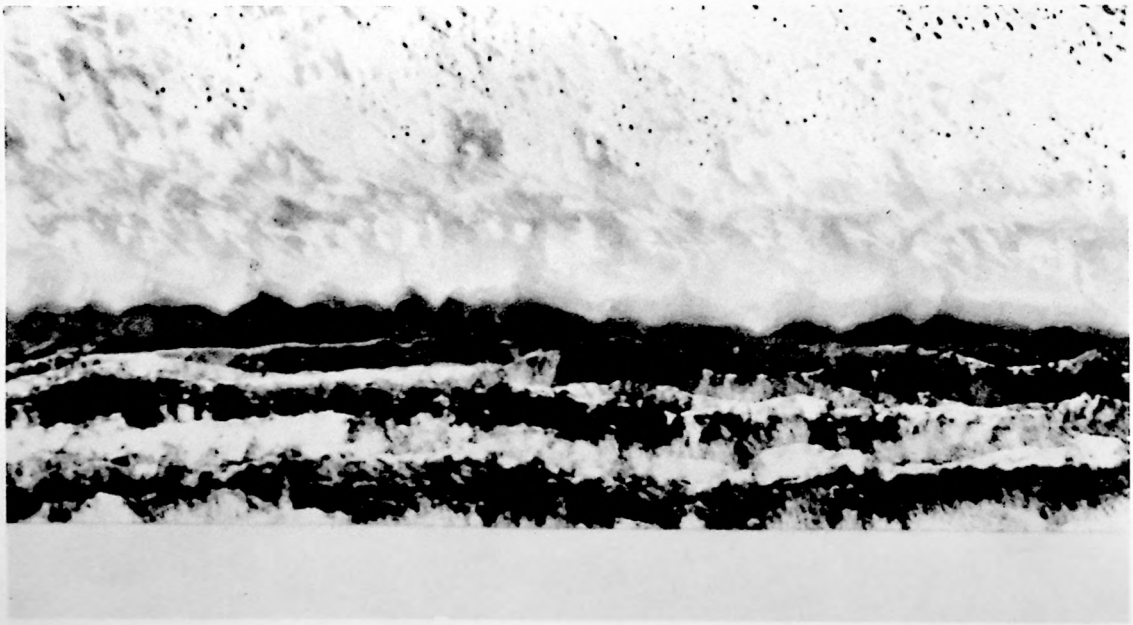


FIG. III–67. Aerial photograph showing beach cusps.

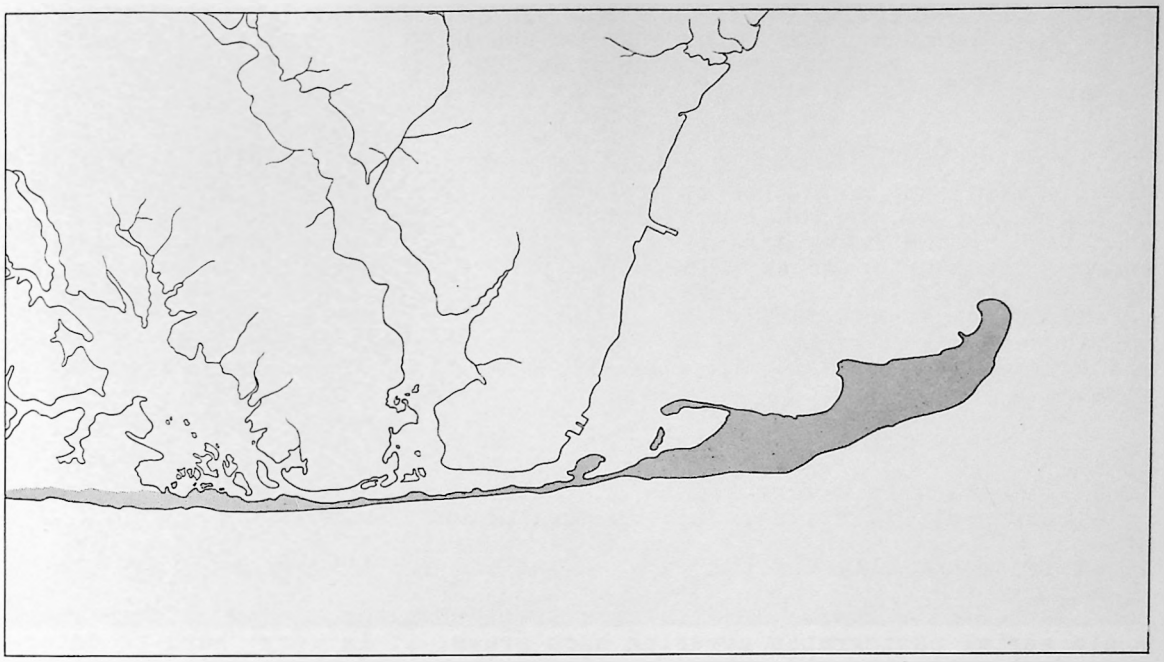


FIG. III-68. Chartlet of Sandy Hook—an excellent example of a compound spit.

FIG. III-69. Chartlet of Cape Cod—another excellent example of a compound spit.

2. Nipa palm generally grows in areas that are usually submerged at high tide. Therefore, the outer edge is the only recognizable shoreline, and this is the line that is delineated. However, this line will not represent the true shoreline. This will be more thoroughly discussed in Chapters that follow.

(b) *Wild Cane:*— The main reason for carrying a description of wild cane in this manual is to try and illustrate the difference between it and nipa plam. On small scale photographs the difference is so slight that it is sometimes erroneously marked. Wild cane usually grows in swampy fresh water areas which are a part of a low-lying coastal plain or river plain, and, as a rule, is limited to small sites which may be covered with several feet of fresh water. It is a tall grass plant, attaining a maximum height of 12 feet, and is light green in color with a white tassel of flowers. Fig. III-71 shows wild cane along a meandering stream.

Important points to remember about wild cane:

1. It is generally recognizable on aerial photographs by its felt-like appearance, light tone, uniform height, and swampy location.

2. It is essentially a fresh water plant and isn't found in tidal flats.

(c) *Rain Forest:*— In some areas of mangrove, and on some small scale aerial photographs covering such areas, it is very hard to determine just where the old mangrove discontinues and where rain forest begins. It is hoped that a few photographs of this type of growth will aid in separating the two. Rain forest is essentially a hard-ground vegetation growth, common in rolling country, along stream banks, and at edge of mangrove swamps. Usually, in addition to the tall mixture of hardwood trees, the area is covered with a dense understory of tangled shrubs, creepers, vines, palms, and other plants ranging up to 20 feet in height. The stand is not uniform in age or height until the mature rain forest type develops with a dense crown canopy that will then choke out the underbrush. Figures III-72, III-73 and III-74 are illustrations of typical rain forest areas.

Important points to remember about rain forests:

1. It is generally recognizable on aerial photographs by its mottled appearance as the mixed stands contain species of different tones. The general tone is lighter than mangrove and the texture is rough or irregular due to variation in size and height of the trees.

2. It does not grow in brackish water.

(d) *Mangrove:*— Of all tropical vegetation, the mangrove gives the photogrammetrist the most trouble. The common mangrove forest abounds on tropical shores throughout the world. The trees thrive along tidal estuaries, in salt marshes, and on muddy coasts; and are composed of shrubs as well as trees in heights up to 75 feet. Their trunks and branches constantly produce adventitious roots which, falling in arched fashion, strike at some distance from the parent stem and send up new trunks, the forest thus spreading thickly over the tidal mud. Another reason for their thick and rapid spread is the fact that the seeds of the fruit sprout before they drop and are able to propagate new plants as soon as they touch the ground. The mangrove is a salt-water plant and

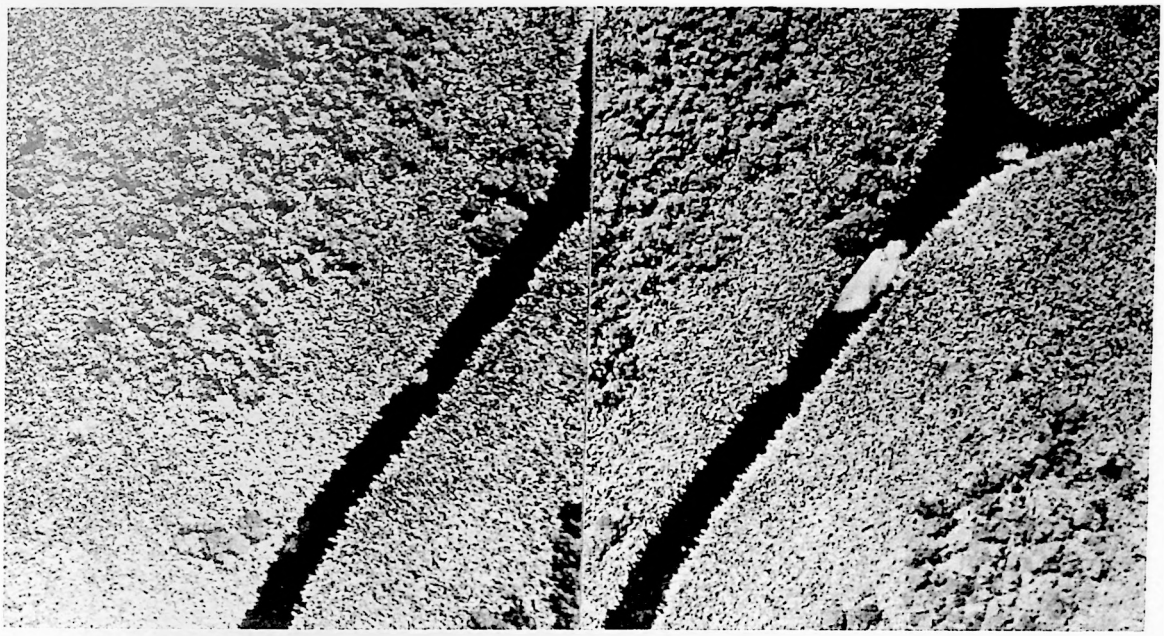


FIG. III–70. Aerial photographs showing nipa palm.

FIG. III–71. Aerial photographs showing wild cane.

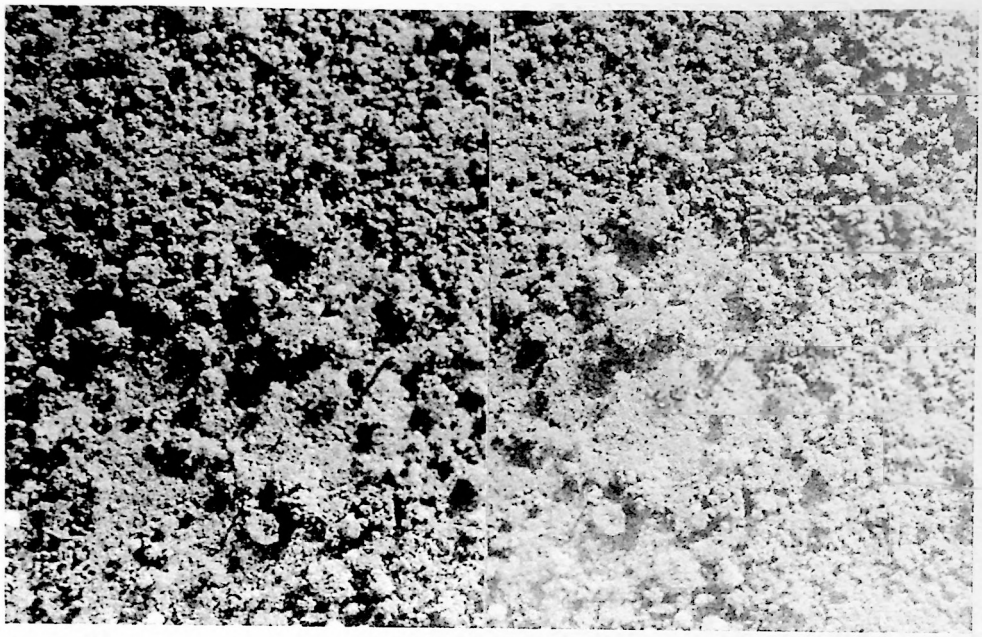


FIG. III-72. Aerial photographs showing rain forest.

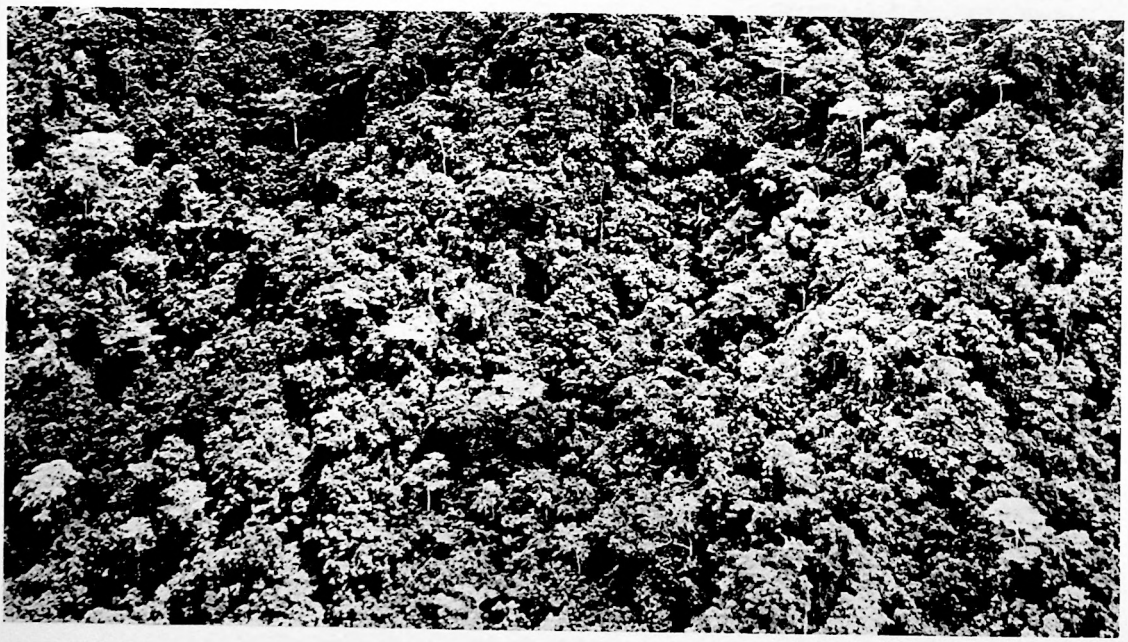


FIG. III-73. Aerial photograph showing rain forest with a small amount of undergrowth.

is not found beyond the limits of brackish water, but thrives along muddy coast lines between the limits of low and high tides. Since the trees grow close together, the roots and trunks form a dense tangle that is almost impossible to penetrate. At low tide, the ground is often thick mud, varying in depth from a few inches to several feet. Generally, the mangrove swamp will have numerous small, but often deep, water courses meandering within it. On the inner edge of the swamp, the mangrove trees are larger and will often merge with the rain forest. Figures III-75 and III-76 are typical examples of mangrove swamps.

Important points to remember about mangrove:

1. It is generally recognizable on aerial photographs by its position along tidal flats and muddy brackish streams; by its uniform, dark tone; and by its fine-textured, even canopy.

2. Like the nipa palm, it generally grows in between low and high tide areas. Therefore, the outer edge is the edge that is delineated as the shoreline, since this is the edge that the navigator of a ship would use in obtaining bearings for determining his ship's position.

3. The inside limit of the mangrove generally establishes the limit of high tide and is the actual shoreline. When this line can be determined from the aerial photographs, it is delineated as a dashed line.

VI. MAN MADE SHORELINE:— The proper delineation and symbolization of these features will be discussed in detail in the following chapters.

FIG. III-74. Another aerial photograph of rain forest with undergrowth. Note the variation in tree heights and density of understory.

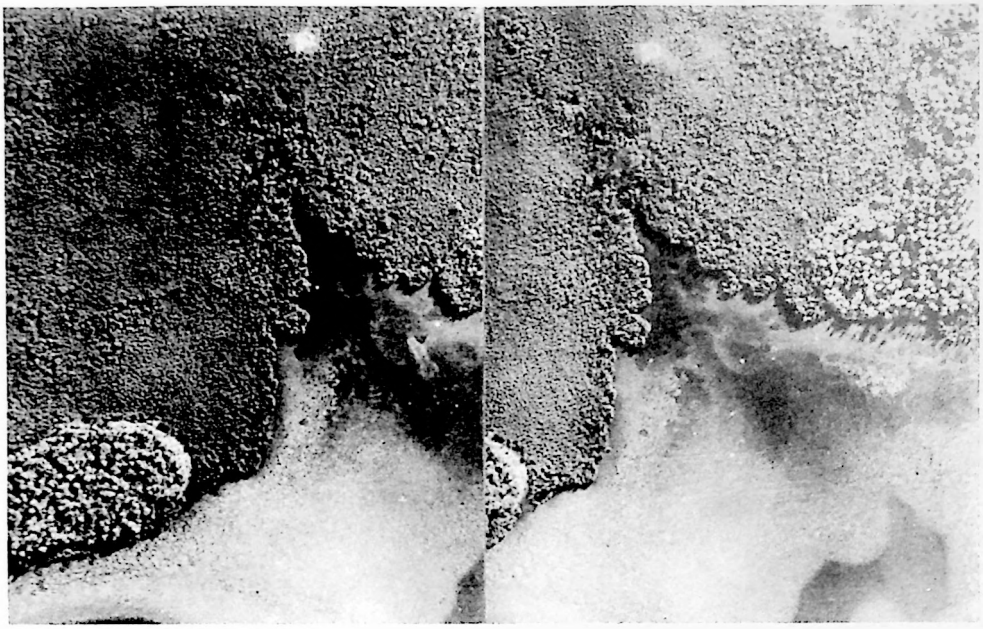


FIG. III–75. Aerial photographs showing a mangrove swamp.

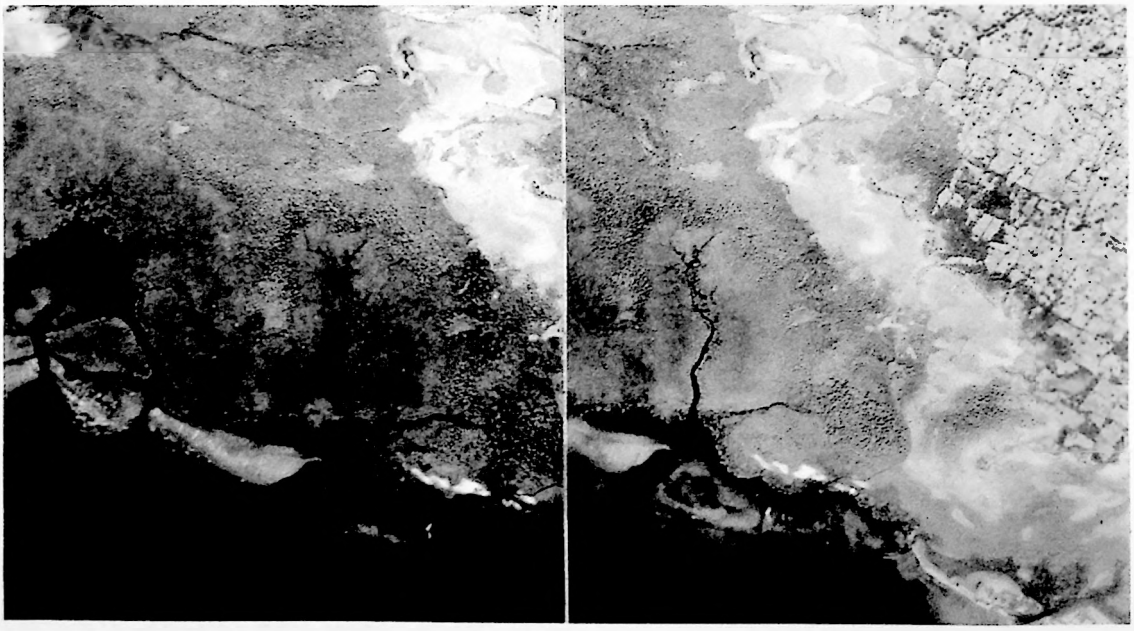


FIG. III–76. Another stereo pair of aerial photographs showing a mangrove swamp.

CHAPTER IV

COASTAL ITEMS TO BE MAPPED

All features that can be seen on an aerial photograph are to be transferred to the manuscript sheet whether or not they can be definitely identified. Whenever possible, all items should be identified as being one of the items listed herein. Occasionally, an area of discoloration will appear on the photograph, in the offshore zone, which cannot be identified as any particular item. The delineator, in this case, should outline the area as a danger area, and transfer it to the manuscript sheet. When combining the photogrammetric work with the hydrographic soundings, the cartographer should then use his own judgment as to whether or not the area should be carried on the chart.

The shoreline appearing on hydrographic charts is, as near as can be determined, the high water line. There is at least one exception to the above statement. Where vegetation, such as mangrove, nipa palm, and prominent marsh grows in the area between low tide and high tide, the outside limit of this growth is delineated as the shoreline. To a navigator, this is the line he sees as the shoreline, and is the line on which he takes bearings when determining the position of his ship. Therefore, the outside limit is carried on nautical charts as the true shoreline and when the inside limits of mangrove and nipa palm can be determined, they are delineated as a dashed line, which will also delineate the line of hard ground.

There is one important phase of delineating coastal features on aerial photographs that should be stressed - the difficulty of determining the approximate depths of underwater features. The photogrammetrist, cartographers, and hydrographic engineers should always keep this in mind when, as a team, they are preparing and compiling data for nautical charts. The present types of aerial photographs and equipment make it extremely difficult to determine the approximate depths of underwater features. The following discussion is very important to persons who are combining photogrammetric manuscript sheets with hydrographic data to form a nautical chart. The photogrammetrist will, and should, according to the best of his ability to interpret, show on the photogrammetric manuscripts all features of the coastal area that seem to uncover at low tide. The areas out beyond this uncovering limit that appear dangerous to navigation should also be delineated. This will be shown on the manuscript as a danger line. For example, along a coral reef, he should show that part of the reef that appears to uncover, to the best of his ability. This, of course, will be shown on the manuscript in its proper symbolization. Out beyond this, that portion of the reef which shelves out into deep water can often be seen. The extremities of this visible shelf should be shown as a danger line. It must be remembered by the cartographer that, although these features are delineated to the best ability of the photogrammetrist, the accurate interpretation of such features is limited by the quality and scale of the photographs as well as the difficulty of determining depths of water from photographs. It is quite likely that when this information is combined with the hydrographic data it will conflict with the soundings. If the soundings are reliable, then the uncovering portion and the danger line should be moved to agree with the soundings. If, in the cartographer's opinion, the sounding

data is not very reliable, he should use extreme caution in shifting the photogrammetric data.

This delineation problem is considered of sufficient importance to relate, at this point, two outstanding experiences. The writer was delineating on a photograph the coral pillars in an atoll, and was of the opinion that most of them would uncover at low tide. Later, he discovered that the sounding party had stopped the sounding boat over most of these pillars and had obtained depths of from two fathoms (12 feet) to fifteen fathoms (90 feet). Another time, the writer was delineating a coastal area which had a rock ledge extending into the water. The best interpretation of the photographs seemed to indicate that only a small part of the ledge would uncover and the balance indicated an underwater danger. Soundings revealed that the ledge actually uncovered out to the limit of the danger line.

The above examples are given in order to stress the point that the approximate depths of underwater features are very hard to determine on aerial photographs. If the hydrographic engineer field edits as many of these features as possible; and the photogrammetrist uses the field man's information as well as considerable judgment in delineation; and the cartographer employs caution and skill in combining the photogrammetric data with the hydrography, a nautical chart will result which will be safe for peacetime navigation as well as for amphibious operations.

The items listed herein are intended to include all coastal features-from and including-the marine cliff seaward into the offshore zone as far out as objects can be seen on an aerial photograph. Generally, all backshore and most of the foreshore features can be identified without any difficulty. It will sometimes be difficult to determine the exact limits of some of the foreshore and offshore features. At times, it will be very difficult to classify the type of danger within an area assumed to be dangerous to navigation.

The items to be mapped have been broken down and listed as either a backshore, foreshore, or offshore feature. It is realized that some of the items will actually fall within two or more of these zones. The name of the item is listed with a shore description and, whenever possible, a stereo-pair of photographs is carried to show how the item usually appears on the photograph. The proper manuscript symbols for these items will be found in Chapter V.

BACKSHORE ITEMS

(a) *Cliffs:*— This is intended to mean merely the marine cliff along the coastal areas. A cliff should be shown on nautical charts wherever it is of ample height to hamper landing operations or when the cliff is conspicuous and would be used by a navigator in making a "landfall". In these cases, a cliff symbol should be shown on the manuscript sheets. Care should be taken so as not to confuse steep slopes, which can be properly portrayed by contour lines, with the more precipitous cliffs. Occasionally the cliff symbol will be used between contours where sharp escarpments are not depicted by the regular interval contour. Along many of the world's coastal areas, the high water mark of the sea will be on the marine cliff, as shown in Fig. IV-1. In other

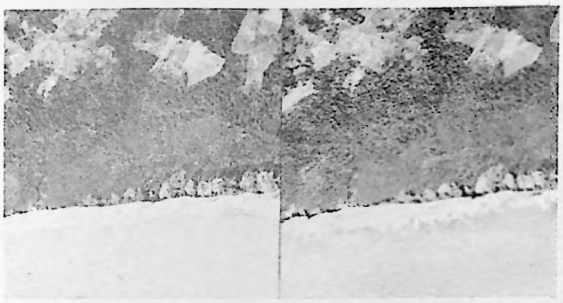


FIG. IV-1. Stereo-pair of photographs showing a cliff which borders the shoreline.

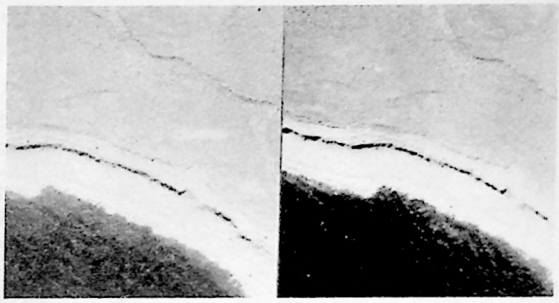


FIG. IV-2. Stereo-pair of photographs showing a cliff some distance from the shoreline.

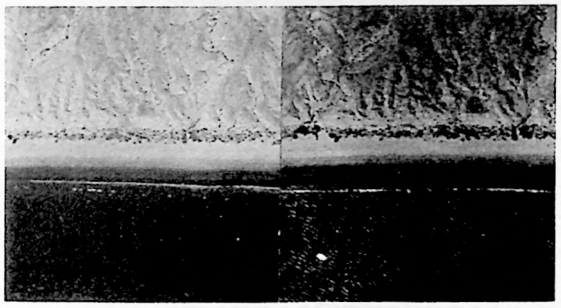


FIG. IV-3. Stereo-pair of photographs showing a backshore beach of sand.

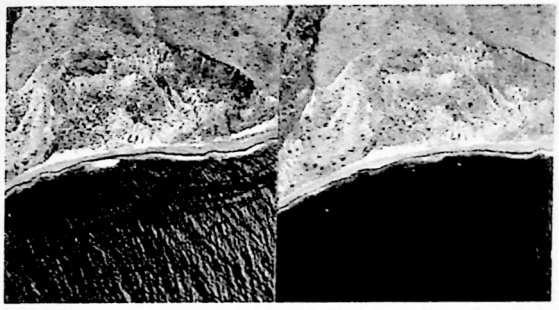


FIG. IV-4. Stereo-pair of photographs showing a backshore beach of shingle.

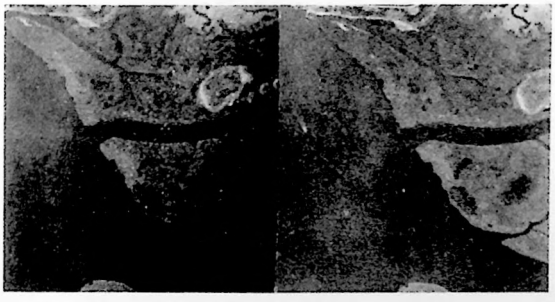


FIG. IV-5. Stereo-pair of photographs showing marshland along the backshore area.

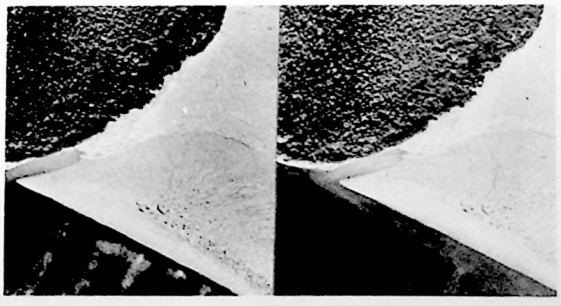


FIG. IV-6. Stereo-pair of photographs showing mud along the backshore area.

areas where the coast is exposed to heavy wave erosion and weathering conditions, the shoreline will be some distance in front of the cliff, as shown in Fig. IV-2. This distance will vary from a few feet to a hundred or more feet depending upon whether the shore is being built by ocean abrasion, by sea currents which are depositing the debris to and from other areas; whether the wave and sea currents can transport the debris being eroded and weathered from the cliff, or from numerous other combinations of conditions that could be occurring.

(b) *Beach:*— The backshore beach, as noted in Chapter II, is that portion of the land lying between the shoreline and line of wave-deposited debris. The composition of the beach may be made up of sand, shingle, marsh, mud, or areas subject to inundation and glaciers. If the composition is known, the beach should be symbolized on the manuscript sheet according to the symbols shown in Chapter V. It is to be noted that only those items that are to be symbolized on the manuscript sheet are listed herein. In other words, the composition of the backshore beach may be made up of land features other than those listed and since they are not usually symbolized on the manuscript, they are not considered.

(c) *Sand:*— Sand may be identified on the photographs by its smooth texture and the tone which is usually much lighter than other features of the land, see Fig. IV-3. This is not true of some areas of the world where the sand does not reflect the light as well as it does in other regions. As a rule, it may be detected by its smooth texture.

(d) *Shingle:*— Shingle is made up of boulders, gravel, and sand. It is usually identified on the photographs by its rough uneven texture and grey color as shown in Fig. IV-4.

(e) *Marsh:*— It is very difficult to interpret marsh on small scale photographs. Under various light conditions and in certain seasons of the year, a marsh area may be overlooked entirely in the delineation process unless the photographs are field edited, or other data is available that will designate the marsh areas. Fig. IV-5 is an example of marsh.

(f) *Mud or Land Subject to Inundation:*— Such areas may be the result of various conditions, which generally result in alternating periods of inundation and drying. They may be detected on the photographs by a smooth texture and dark grey color during the "wet" period; and in the dry period, by the small stream patterns dissecting the surface giving a dried and cracked appearance, and by the lighter grey color. Examples may be found along coastal areas where tidal wash does not readily drain off; where delta growths have built up but are still subject to inundation; and where seasonal rains inundate areas of poor run-off. Figures IV-6 and IV-11 illustrate these conditions.

(g) *Glaciers:*— Glaciers are easily identified on an aerial photograph by their white, rough texture, and by the deep crevasses in the surface of the ice, Fig. IV-7. The face of the glacier usually drops perpendicularly into the sea.

(h) *Sand Dunes:*— The shore sand dunes are extensively developed along some of the coasts of the world reaching, in some instances. heights

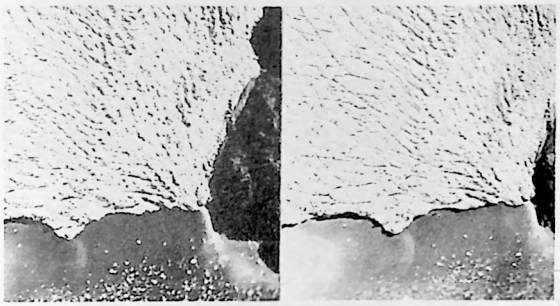


FIG. IV-7. Stereo-pair of photographs showing a glacier along the backshore area of a fiord.

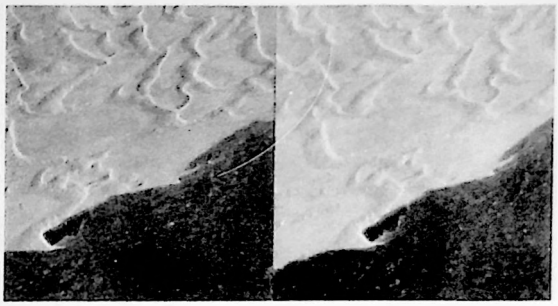


FIG. IV-8. Stereo-pair of photographs showing sand dunes along a coastal area.

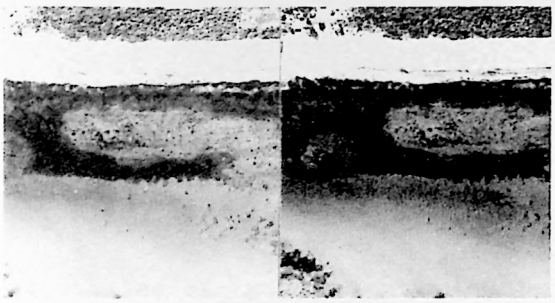


FIG. IV-9. Stereo-pair of photographs showing an area in which it is difficult to determine the high water mark.

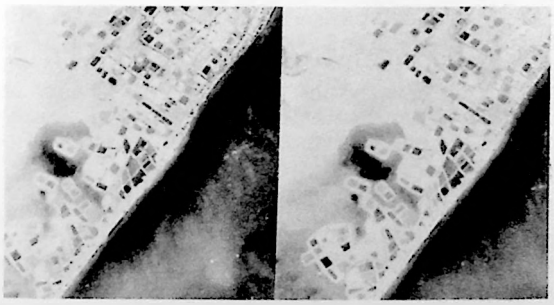


FIG. IV-10. Stereo-pair of photographs showing salt pans.

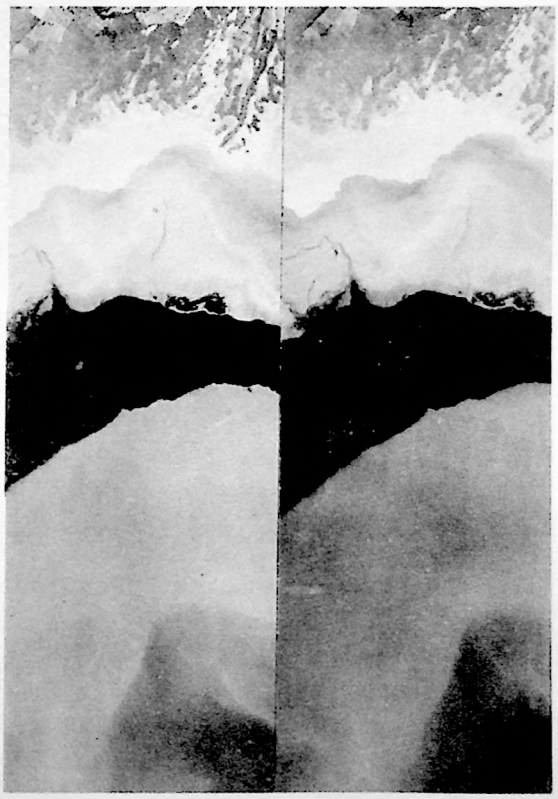


FIG. IV-11. Stereo-pair of photographs showing an inundated area in back of a typical mangrove swamp.

of two or three hundred feet. These dunes are the produce of wind action and tend to move in response to its action so as to present a shifting equilibrium profile. Fig. IV-8 shows a typical sand dune shore.

(*i*) *Shoreline:*— The exact position of the high water mark on the coast is, in some areas, very difficult to determine on aerial photographs. If the high water mark borders on a marine cliff, as shown in Fig. IV-1, the horizontal position of the shoreline may be established on the manuscript sheet very accurately, since a small error in the interpretation of the position of the high water mark on the photograph will not affect its accuracy on the manuscript sheet. If, on the other hand, the high water borders a gradual sloping beach, as shown in Figures IV-2, IV-3, IV-4, IV-6, and IV-9, the exact position of the high water mark is very difficult to determine on an aerial photograph. Usually, if the area is studied under a magnifying stereoscope, two lines of slight discoloration will be seen along the beach. The inshore line is the line of wave-washed debris and will usually be a little more distinct than the outer line which is the high water line. In some areas where the force of the waves is broken up before reaching the shore, the debris line and the high water line will be the same. In other areas where waves of different magnitude and force are beating against the coast, the debris line will be at varying distances from the high water line. Therefore, the characteristics of the wind and the offshore depths of water should be studied before trying to determine the high water line along a low flat coastal area. It is almost impossible to distinguish these two lines (debris and high water) from single photographs.

(*j*) *Salt Pans:*— In some areas, natives are obtaining salt from the sea water by evaporation. Small areas are isolated by a series of dikes within which sea water is allowed to enter. The dikes are then closed and the sun is allowed to evaporate the water leaving the salt deposits. These areas are easily detected on an aerial photograph as will be seen from Fig. IV-10.

(*k*) *Mangrove Swamps:*— Strictly speaking, a mangrove swamp is not a backshore feature because it usually grows in the area between low and high tide. Since nautical charts show the outer limits of mangrove as the shoreline, this manual considers it a backshore feature. The common mangrove swamps abound on tropical shores throughout the world and are found along tidal estuaries, in salt marshes, and on muddy coasts. At low tide, the ground is often thick, deep mud impossible to penetrate except for small deep-water courses that meander within the swamp. It is usually easy to recognize mangrove areas on aerial photographs by their positions along tidal flats and muddy brackish streams; by their uniform dark tone; and by their fine-textured, even canopy. Fig. IV-11 shows a typical mangrove swamp.

(*l*) *Nipa Palm:*— Similar to mangrove, the nipa palm is, strictly speaking, an offshore feature but is carried in this manual as a backshore feature. It is usually discernable on aerial photographs by its feathery appearance, light tone, uniform height, and swampy location. The outer edge is the line that is delineated as the shoreline. Fig. IV-12 shows a typical nipa palm area.

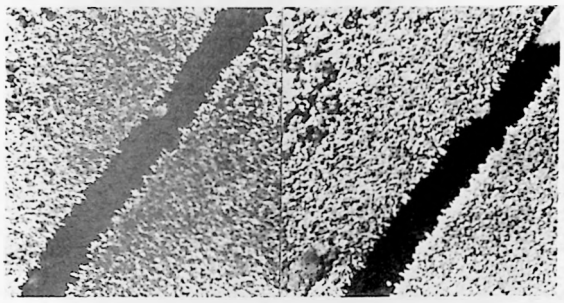


FIG. IV-12. Stereo-pair of photographs showing nipa palm.

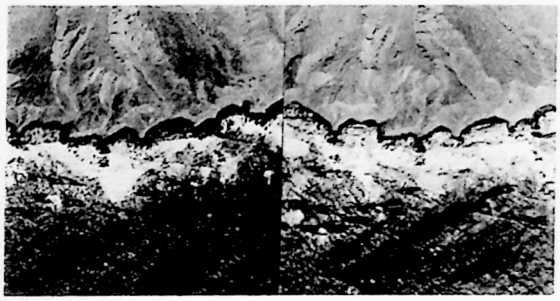


FIG. IV-13. Stereo-pair of photographs showing small "pin point" islands or rocks.

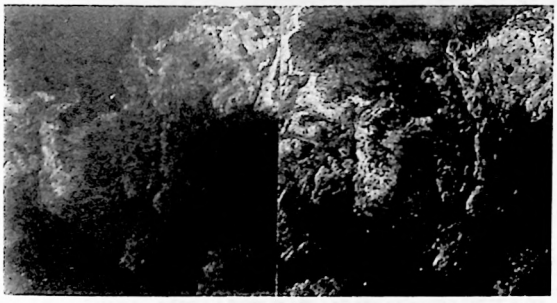


FIG. IV-14. Stereo-pair of photographs showing a typical rocky ledge.

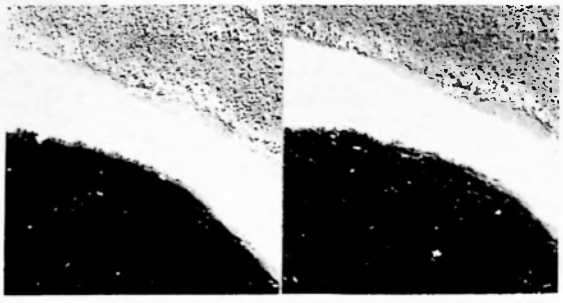


FIG. IV-15. Stereo-pair of photographs showing a typical coral ledge.

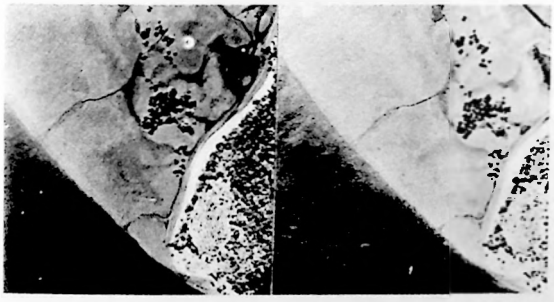


FIG. IV-16. Stereo-pair of photographs showing mud which covers and uncovers with the tide.

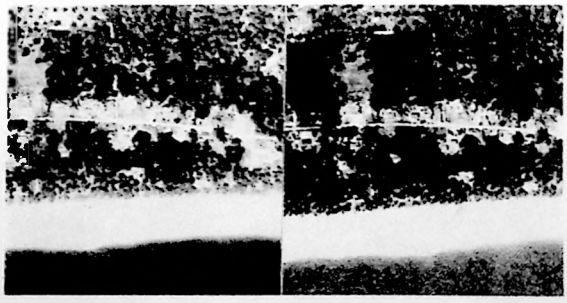


FIG. IV-17. Stereo-pair of photographs showing foreshore beach sand.

(m) *Islands, Islets and Rocks:*— These items are not, strictly speaking, a part of the backshore area. Since they are above the line of high water and would be encompassed by a shoreline, in this manual they are considered a backshore feature. Actually, all three of these items are islands. If the island and the photogrammetric compilation scale are large, the island would have a shoreline, beach, backshore, and foreshore area the same as a large continent. Therefore, whenever the scale of the photographs and the size of the islands will permit, the type of beach and the backshore and foreshore features of the island should be shown. Whenever the islands are too small, and the compilation scale is such that it will not permit showing an uncoalesced shoreline, the islands are usually referred to as rocks. Rocks of this type are more prevalent along submergent, fiord, and volcanic coastal areas although they may be found along any type of coast. The photogrammetrist should scan the photographs very carefully to insure locating all rocks in an area. Fig. IV-13 shows a typical example of small islands or rocks along a coast. In delineation, the general policy will be to retain as many of these rocks, drafted as dots, as scale will permit. The inclusion or exculsion of rocks must necessarily be left to the discretion of the compiler. He will be guided by the following general rules:

Rocks or single "pin-point" islands lying away from the shore will be retained because of their isolation and relative danger to navigation.

Single "pin-point" islands lying close to the shore will be retained unless, when accurately plotted, they coalesce with the shore.

"Pin-point" islands in group formation will be retained except when the islands coalesce. In such instances retain first, the larger of the group; second, those which complete a general representation of the group.

"Pin-point" islands which, because of their size may, become lost in open water or mistaken for spots will be encompassed within a danger line or labeled "Rocks".

FORESHORE ITEMS

(a) *Beach:*— The foreshore beach, as noted in Chapter II, is that portion of the coast lying between low and high water. This is understood to mean the area which is a continuation of the backshore beach. It does not include the areas which are detached from the general beach. The composition of the foreshore beach may be made up of a rocky ledge, Fig. IV-14; coral reef, Fig. IV-15; mud, Fig. IV-16; sand, Fig. IV-17; or shingle, Fig. IV-18. If the composition is known, the beach should be symbolized on the manuscript sheet according to the symbols shown in Chapter V. It is to be realized that only those items that are to be symbolized on the manuscript sheets are listed herein. In other words, the composition of the foreshore beach may be made up of other land features besides those listed herein. Since they are not usually symbolized on the manuscript, they are not considered in this manual. Rocky ledges are usually found along most of the submerged ria, vol-

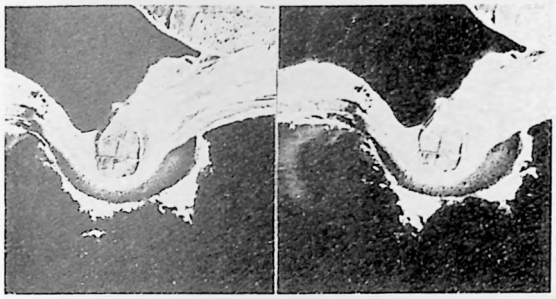


FIG. IV-18. Stereo-pair of photographs showing a shingle foreshore beach.

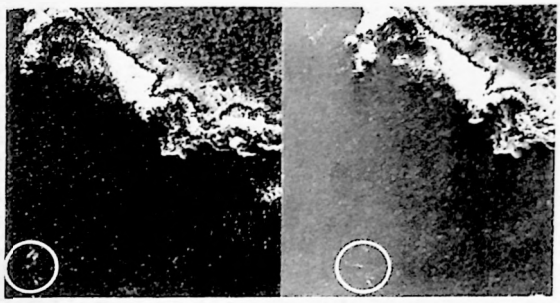


FIG. IV-20. Stereo-pair of photographs showing a small detached rock which uncovers.

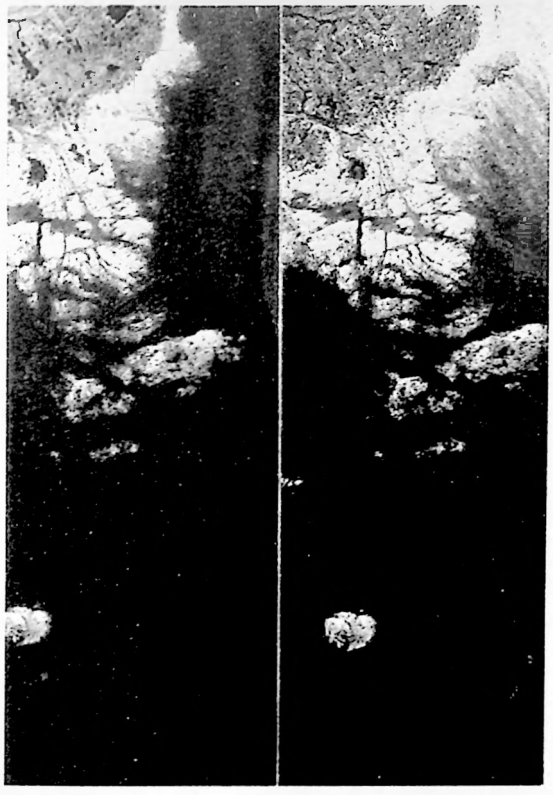


FIG. IV-19. Stereo-pair of photographs showing large rocky areas which uncover.

FIG. IV-21. Stereo-pair of photographs showing a typical coral reef with coral "pillars".

canic, and fiord coasts. The extent to which the ledge is uncovered is generally governed by the amount of tide in the area. The rocky ledge is usually identified on an aerial photograph by its light grey color, rough texture, and by crevices crisscrossing the face of the rock. Coral ledges, or coral reefs, as they are more commonly known, are the coral rocks that are formed by small marine organisms. A coral reef may range from a few feet to two or three miles in width. It is easily recognized on an aerial photograph by the grey to almost pure white color. Coral, with the exception of the eastern part of the tropical Pacific and nearly the whole breadth of the tropical Atlantic, is found quite extensively along most of the coasts of the world that lie between the 30° latitudes. Beach mud is commonly found along the foreshore river delta areas and the outwash plains. It is part of the alluvium that is deposited into the sea by rivers and gradually filling the bays and coves. It is usually recognized on a photograph by its fine texture, its dark to light grey color, and by the fact that it is generally found at river mouths. The extent of foreshore beach mud may be quite large having large and small channels dissecting the area, which is kept open by the force of the streams entering the sea. Foreshore beach sand will vary in color on a photograph from a grey to an almost pure white. It has a fine texture and is found in bay heads, bars, spits, and along emergent coasts. Shingle is made up of boulders, gravel, and sand, and is quite common in glaciated areas, along the more recent volcanic coasts, and along the mature submergent and emergent coasts. It may be detected on the photograph by its rough, uneven texture, and dark color.

(b) *Detached Foreshore Items:—* Along all coastal areas, there are large and small isolated areas detached from the backshore and foreshore beaches. Actually, they are a part of the general beach, but are of such formation that at low tide, water will surround them in a manner in which they will be isolated from the general beach. These items are usually rocks, coral, mud, and sand. The large rocky areas, which are shown in Fig. IV-19, have the same characteristics on the photographs as the rocky beach and should be symbolized on the manuscript sheet as a rock reef. The smaller rocks, which are usually detected on an aerial photograph by the waves breaking over and around them, as shown in Fig. IV-20, will be symbolized as a "rock awash". These partially submerged rocks are very dangerous to navigation, especially if they lie in or close to ship or boat channels. Therefore, the photographs should be examined very carefully so that all such rocks are located. These small rocks, because of the size of the symbol used on the manuscript may become lost in open water and should be encompassed within a danger line or labeled "rocks". Coral reefs which are detached from the foreshore beach, as, for example, barrier reefs, atoll reefs, and small isolated reefs found within coral lagoons, have the same characteristics on the photographs as the coral beach. They should be symbolized on the manuscript sheets by their proper coral reef symbols. Fig. IV-21 shows this type of coral reefs. If the coral reefs or "pillars", usually found within coral lagoons, are too small to show by the coral reef symbol and if they will uncover at low tide, they should be shown on the manuscript by a "rock awash" symbol and treated in the same manner as small rocks. Detached mud banks or bars, Fig. IV-22, and sand bars, Fig. IV-23, which uncover at low tide should be shown according to the proper symbol given in Chapter V. These features have the same characteristics on an aerial photograph as foreshore beach, mud, and sand, respectively.

FIG. IV-22. Stereo-pair of photographs showing a mudbank which uncovers.

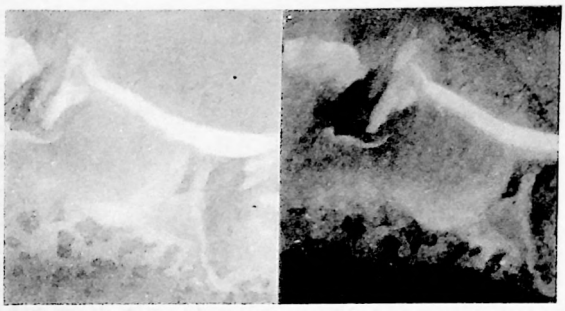


FIG. IV-23. Stereo-pair of photographs showing a sand bar which uncovers.

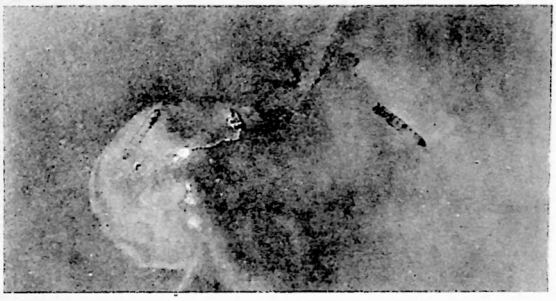


FIG. IV-24. Aerial photogragh showing wrecks. Note the dredge blowing sand from the channel.

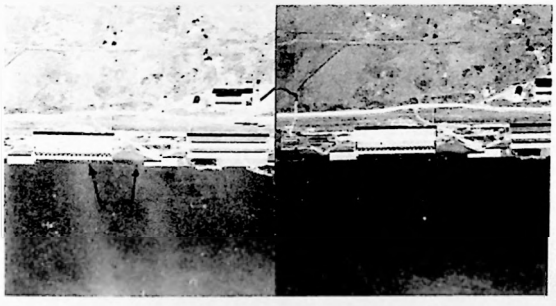


FIG. IV-25. Stereo-pair of photographs showing piles.

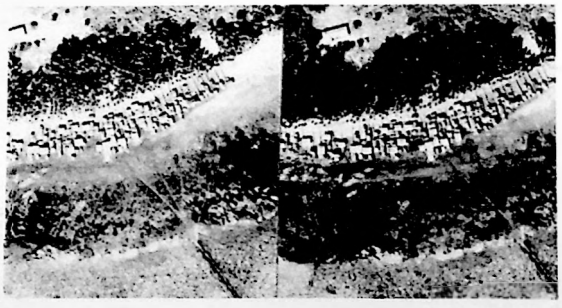


FIG. IV-26. Stereo-pair of photographs showing native huts.

(c) *Unnatural Foreshore Items:—* The unnatural, or artificial, foreshore items, such as wrecks, Fig. IV-24; piles, Fig. IV-25; huts, Fig. IV-26; fishing traps, Fig. IV-27; and reclaimed areas - where the reclaiming process is underway - Fig. IV-28, are features of the foreshore area apart from the actual physical features which were listed under "a" and "b". Wrecks which are considered herein are the wrecked ships or boats of which any portion is above low water. They are navigation hazards and should always be shown on the manuscript sheets. Piles may be the remains of an old abandoned pier or they may be the beginning of a marine structure. They are very hard to see on an aerial photograph and may be missed entirely if the photographs are not edited in the field. Some tropical natives will build huts - sometimes whole villages - out over the foreshore area. These huts are usually easily identified on the photographs and should be shown on the manuscript sheet. Fishing traps, found usually in the tropics, are dangerous to landing parties and should be delineated. These traps have peculiar characteristics and are easily detected on the photographs. Within many harbor areas, processes are underway to reclaim additional land space from the sea. When, on an aerial photograph, the beginning of the process of reclaiming an area can be detected, it should be delineated because it will not only show an obstruction but will indicate future expectations in the general area.

OFFSHORE ITEMS

(a) *Danger Areas:—* Since the exact depths of underwater features cannot be accurately determined from small scale photographs, the photogrammetrist should delineate and transfer to the manuscript sheet all discolored areas lying in the offshore zone. Usually, it will not be possible to determine whether or not these areas are actually danger areas. Nevertheless, these discolored areas will be shown on the manuscript sheets. When the cartographer combines this data with that of the hydrographic survey, it will then be decided how the area shall be charted. For example, the photogrammetrist may be able to detect a submerged sand bar, rocky reef, coral reef, etc., in the offshore zone of an area. The cartographer may decide when compiling the chart of the area that due to the characteristics of the coast everything inside the six-fathom curve would be considered dangerous, and he would construct the chart to show this condition. If the soundings in the area were considered reliable, and the danger area which was delineated by the photogrammetrist falls outside the six-fathom curve, the cartographer should disregard this danger. If, on the other hand, the soundings were not reliable, then the cartographer should, to be safe, show the danger area on the chart. Another condition that may exist is that the photogrammetrist may delineate a danger area which, when combined with reliable soundings, will be larger than the soundings indicated. In this instance, the danger area should be contracted to agree with the soundings. It is entirely possible that a reverse condition will exist where the area should be expanded to agree with the soundings. The point that the writer is trying to establish is that it is impossible to determine the exact depth or the exact limits of submerged areas on an aerial photograph considering the quality of photographs and techniques in use today. Therefore, it is not only essential that the photogrammetrist realize this limitation in coastal delineation but the cartographer should also realize it, and use

FIG. IV-27. Stereo pair of photographs showing fish traps.

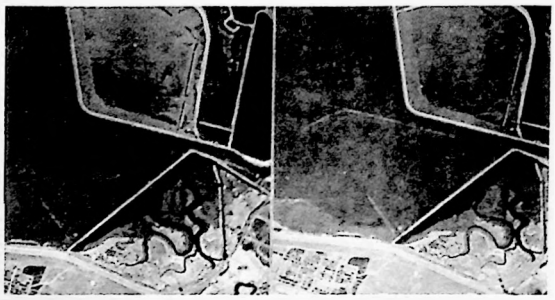


FIG. IV-28. Stereo-pair of photographs showing a reclaim area underway.

FIG. IV-29. Photograph showing area believed to be dangerous for navigation.

FIG. IV-30. Photograph showing area believed to be dangerous for navigation.

the photogrammetric compilations with this understanding. Figures IV-29, IV-30, and IV-31 show three various types of areas which are believed to be danger areas.

(b) *Sunken Rocks:*— Sunken rocks are, to a certain extent, similar to a danger area except that they are usually small. If they fall in between sounding lines and the area is not wire dragged, they are very apt to be missed entirely in the hydrographic survey. These rocks are very dangerous to navigation, especially when they are near the surface of the water, yet too deep to cause the waves to break, and when they lie in or near the normal ship channel. The photogrammetrist should employ every precaution to assure locating every sunken rock within the area covered by the photographs. These small rocks, because of the size of the symbol used to show them, may become lost and should be encompassed within a danger line or labeled "rocks". Fig. IV-32 shows a typical example of a sunken rock.

(c) *Breakers:*— Waves, when approaching the coast, will break on encountering water too shallow for their propagation. After breaking, these waves will be reduced in size and will, by momentum, be forced further toward the coast, breaking again on encountering water too shallow for propagation. In this manner, a train of breakers develops along a coast of shallow water which is exposed to wind waves. Breakers, usually quite prevalent along an emergent coastal area, make landings in small boats quite hazardous. Fig. IV-33 shows a typical example of breakers along an emergent coast, which should be shown on the manuscript sheet. It is very difficult to state definitely when breakers should be delineated and when they should be disregarded. One type of breaker which should not be shown is the "white cap" formed by local storms. This type is shown on Fig. IV-34, and the difference between this type and those shown in Fig. IV-33 is quite distinct. Still another type of breaker which should not be shown is that along rocky coasts of deep water, the waves of which break against the coast. This type is shown on Fig. IV-35. It is usually good practice to show the type of breaker which is shown in Fig. IV-33, whenever it may be seen on the photographs and when the scale of the compilation will allow it to be shown with clarity.

(d) *Kelp:*— This type of kelp refers more specifically to the large brown seaweeds usually found along some of the rocky coasts of the Pacific Ocean. It clings to submerged rocks and will float out, partially submerged, for considerable distances from the rocks to which it adheres. This type of kelp is a very tough seaweed and will foul the propellers and cooling system of small motor driven boats. Kelp is usually found along rocky coasts and can be identified on the photographs by dark stringy patches of discoloration. Fig. IV-36 shows a typical area of kelp.

(e) *Other Offshore Items:*— The following offshore items should be delineated on the photographs and carried on the manuscript sheets whenever the delineator can locate them on the photographs: - tide rips, eddies, piles, submerged wrecks, submarine nets, pipe lines, etc. These and any other items not mentioned herein should be delineated and shown on the manuscript sheets.

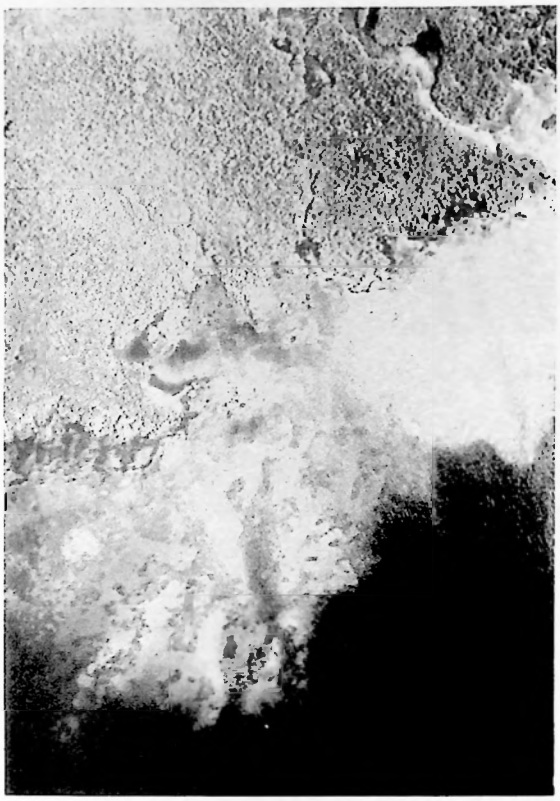


FIG. IV-31. Photograph showing area believed to be dangerous for navigation.

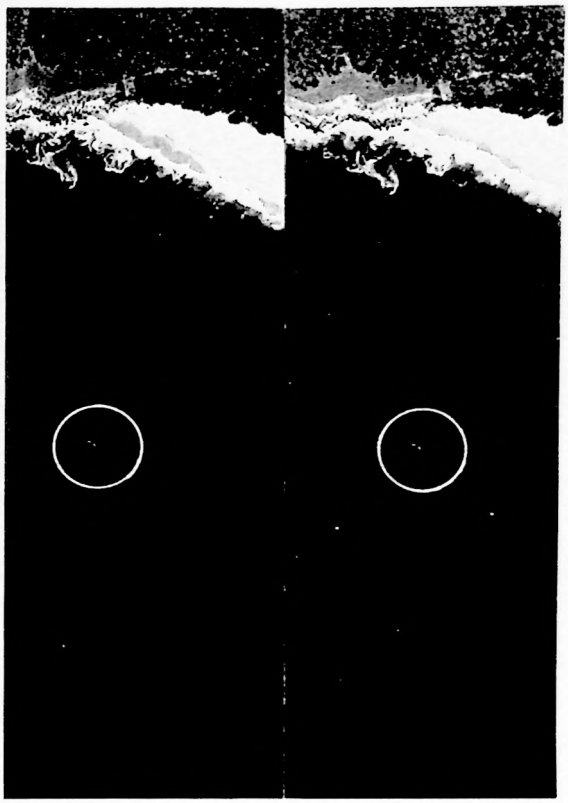


FIG. IV-32. Stereo-pair of photographs showing a sunken rock.

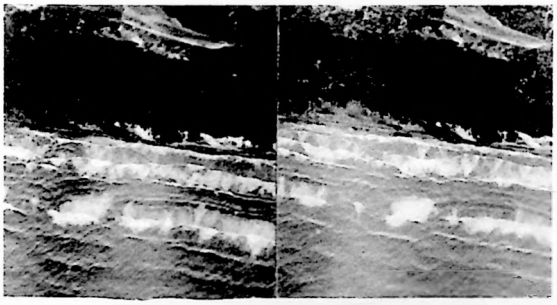


FIG. IV-33. Stereo-pair of photographs showing a typical example of breakers.

FIG. IV-34. Photograph showing "white caps".

MAN MADE FEATURES

Man made features are those items, built by man, which either add to the coast or have been constructed so as to alter the shoreline. These items are docks, piers, breakwaters, seawalls, causeways, marine railways, seaplane landing ramps, etc., to name only a few. Very little descriptive data is required as most of them are easily recognized on an aerial photograph by their straight lines and white color. A few of these items are shown in Figures IV-37 through IV-40.

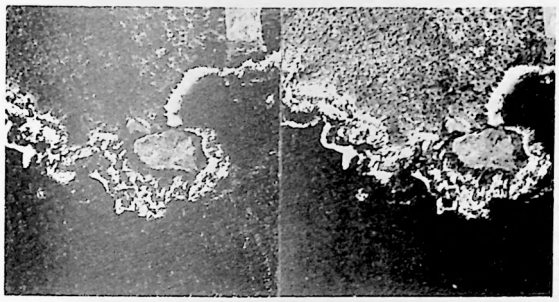


FIG. IV-35. Stereo-pair of photographs showing waves breaking against a coast.

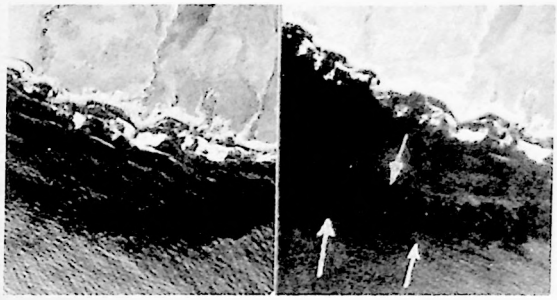


FIG. IV-36. Stereo-pair of photographs showing an area of kelp.

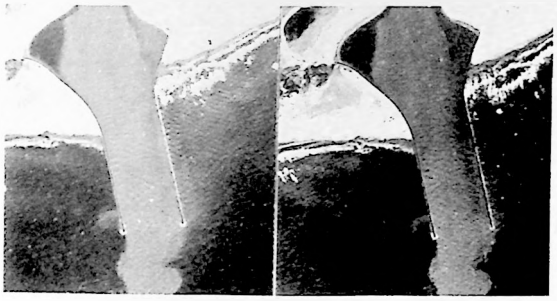


FIG. IV-37. Stereo-pair of photographs showing breakwaters.

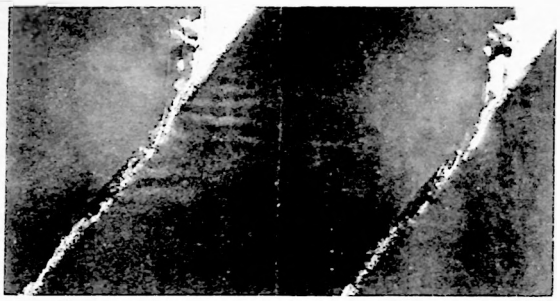


FIG. IV-38. Stereo-pair of photographs showing a breakwater under construction.

FIG. IV-39. Stereo-pair of photographs showing a typical harbor area.

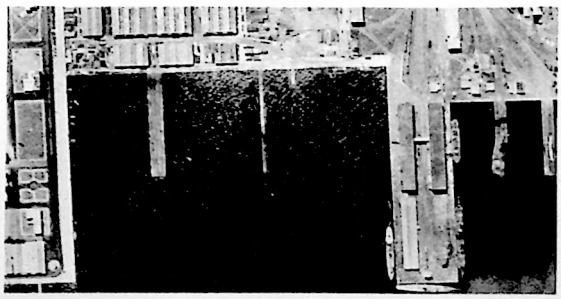


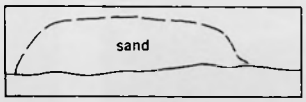
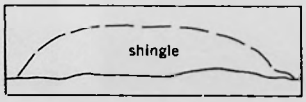
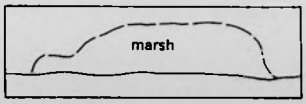
FIG. IV-40. Photograph showing another typical harbor area.

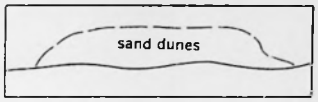
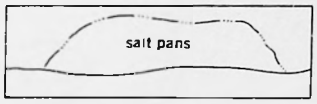
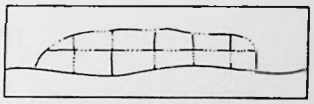
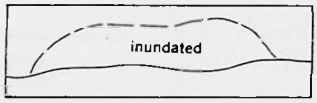
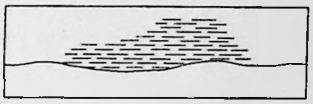
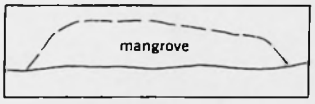
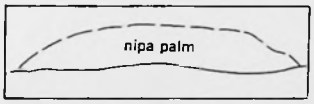
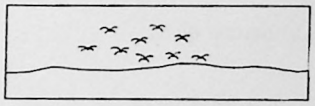
CHAPTER V

MANUSCRIPT SYMBOLS

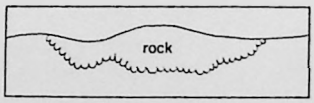
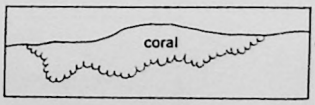
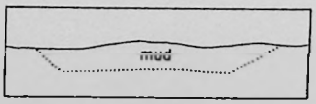
The manuscript symbols, which are shown below, are listed as backshore, foreshore, offshore, or man made items in agreement with the listing carried in Chapter IV. An attempt has been made to anticipate the manuscript symbolization which will shortly be standardized by the Joint Mapping and Photo Committee. Should the standard established by that committee differ from the symbol here shown, it shall automatically supersede this publication. The weights and gauges for these symbols will also be established in the Joint Mapping and Photo committee directive. For clearer picturizations the symbols contained herein have generally been exaggerated.

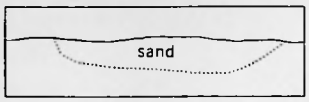
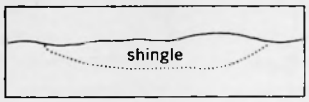
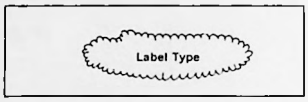
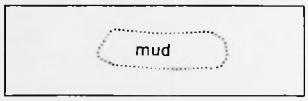
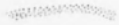
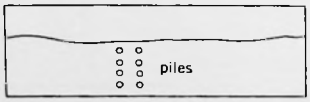
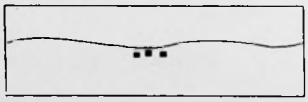
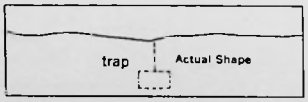
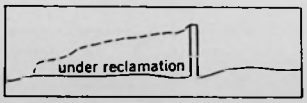
BACKSHORE ITEMS

	Large Area	*Small Area*
1. Cliff		Same
a. Rocky		
b. Not rocky		Same
2. Sand		
3. Shingle		
4. Marsh		

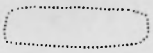
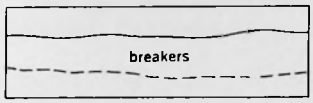
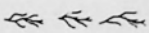
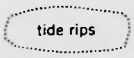
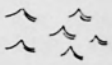
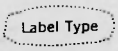
	Large Area	*Small Area*
5. Glacier		Same
6. Sand dunes		
7. Shoreline *Note: When delineating from a single photograph use dashed line.*		Same
8. Salt pans		
9. Inundated area		
10. Mangrove		
11. Nipa palm		
12. Islands, islets or rocks		Same

FORESHORE ITEMS

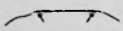
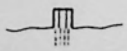
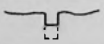
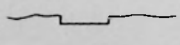
1. Beach		
a. Rock ledge		Same
b. Coral reef		Same
c. Mud flat		Same

	Large Area	*Small Area*
d. Sand		
e. Shingle		
2. Detached items		
a. Rock awash	*	Same
b. Coral reef or Rock ledge		*
c. Mud bank		Same
d. Sand bar		
3. Unnatural items		
a. Wreck		Same
b. Piling		Same
c. Huts		Same
d. Fish trap		Same
e. Area under reclamation		Same

OFFSHORE ITEMS

	Large Area	*Small Area*
1. Danger area		Same
2. Sunken rock	+ or 	Same
3. Breakers		
4. Kelp		
5. Other items		
a. Tide rips		
b. Eddies		Same
c. Submerged piles		Same
d. Submerged wreck		Same
e. Submarine net, pipe line, etc.		Same

MAN-MADE ITEMS

Dock		Same
Pier		Same
Seawall		Same
Marine railway		Same
Seaplane ramp		Same
Wharf		Same

CHAPTER VI

RECOMMENDED PROCEDURE FOR DELINEATION

OF

COASTAL FEATURES

Many years of experience by personnel of the U.S. Navy Hydrographic Office have proved that extreme care must be exercised in delineating coastal features appearing on aerial photographs in order to assure the required accuracy. Therefore, too much emphasis cannot be placed on the importance of rigidly adhering to the recommended procedures contained herein for the delineation of coastal features.

It is considered of sufficient importance to point out again that with the present type of aerial photographs and with the type of equipment in use at present, it is extremely difficult to determine the approximate depths of underwater features. The question that has often been asked is: - "Why doesn't the Navy and/or Army obtain large scale photographs of all coastal areas so that the features can be seen more clearly and depths can be determined more accurately than is possible with the photographs now secured"? In reply to this inquiry, several practical considerations should be noted. First, it must be remembered that almost all of the photography of coastal areas obtained and used by the Army and Navy is outside the continental limits of the United States. The U.S. Coast and Geodetic Survey is responsible for the coastal areas of the United States, its possessions and the Philippines. Obtaining photography of these foreign areas requires a great expenditure of money and time. Secondly, it must be remembered that if larger scale photographs are obtained, a considerably larger number of photographs would be necessary to cover a given area. Consequently, many more flight lines and much more ground control would be required. The job of obtaining adequate ground control is most expensive and time-consuming. The acquisition of large scale aerial photographs for all coastal areas is, therefore, economically impracticable. The U.S. Navy Hydrographic Office specifications for aerial photography, which are essentially the same as the War Department specifications, read, in part, as follows:

> "Basic vertical photography will, in general, be required for all coastal and island areas for Navy large scale charting purposes".
>
> "The camera to be used to obtain the basic photography will be a single-lens mapping camera having a calibrated focal distance of between 151.0 mm and 155.0 mm on a 9 x 9 inch negative".
>
> "The flight altitude, when operationally feasible, shall be accomplished at a corrected altitude of 15,000 or 20,000 feet above mean average terrain, yielding photography of an approximate scale of 1:30,000 or 1:40,000, respectively".
>
> "Supplemental vertical photography is also required to supplement the basic vertical coverage and thereby permit interpretation of planimetry and coastal features in great detail. This will be accomplished for areas of intense culture. Areas of intense culture are defined to include cities, towns, ports, harbors, highly devel-

oped agricultural areas, etc,".

"Supplemental photography shall be accomplished at scales ranging from 1:5,000 to 1:20,000 as specified by the Hydrographic Office, or at the discretion of the unit commander or flight crew".

"On many projects, the best available maps or charts are very inaccurate, and/or lacking in sufficient detail to determine the exact areas and scales where supplemental photography is required. When, therefore, the aerial survey unit notes such areas, which are not selected by the Hydrographic Office, the unit should obtain supplemental photography of such areas using their judgment as to scale and limits thereof".

"Camera to be used for supplemental photography may be any of the following aerial cameras:

"K-17, 6-inch, 9"x9" photograph
K-17, 12-inch, 9"x9" photograph
K-17, 24-inch, 9"x9" photograph
K-18, 24-inch, 9"x18" photograph"

It will be seen from the above quotations that the best compromise has been worked out taking into account all the factors, also, that large scale photographs will be available covering ports and harbors where large scale charts are required.

Another point which will help answer this question is that no satisfactorily "fool proof" method has been devised for obtaining depths of submerged objects from small scale aerial photographs. Under favorable conditions and from extremely large scale photographs, depths may be obtained, but in the present stage of development, the cost and time requirements of this method make it prohibitive except for very small coastal areas.

The writer is of the opinion that if good quality photographs are obtained in accordance with the War and Navy Departments' specifications and if the photogrammetrist follows the below listed procedures, the coastal features will be interpreted and transferred to the manuscript sheet with a high degree of accuracy.

Experience has proven beyond any doubt that for hydrographic mapping, coastal features cannot be delineated within a suitable degree of accuracy from small scale photographs by using any of the stereoscopic plotting instruments, such as the K.E.K. plotter, multiplex, stereoplanigraph, etc. This is due to either a fuzzy image being produced by the instruments or to insufficient stereoscopic magnification that will not permit seeing the shore detail with sufficient clarity to enable proper interpretation. It is, therefore, recommended that all coastal features be delineated on photography by studing the area using a magnifying stereoscope. The type of stereoscope may be either a reflecting or a refracting type. The type is not important just as long as the photo image is enlarged two or three diameters and remains clear. If stereoscopic pairs of photographs are not available, and the shoreline has to be delineated on single photographs, the area should be symbolized as "approximate" as indicated in Chapter V. The shore features cannot be delineated within the required accuracy on single photographs.

Regardless of whether the compilation is done by multiplex, stereoplanigraph, K.E.K., or by any other method, the procedure for interpreting coastal features on the photographs and transferring those features to the manuscript sheets should be as follows:

1. In areas where hydrographic surveys are being made, the field party should annotate the photographs in a manner that will clarify the following: highwater line, type of beach, extent of the foreshore area, type of vegetation along the coast, and any and all types of dangers to navigation.

2. In the process of bridging or extension of photogrammetric control, a sufficient number of photo control points should be established on the manuscript sheet along the shoreline and foreshore features to insure the accurate horizontal positioning of these items.

3. The persons charged with the interpretation and delineation of the coastal features on the photographs should first study all available charts and maps of the area as well as the Coast Pilots and Sailing Directions regarding that particular coast. If available, field-annotated photographs should also be studied. In this manner, he will get a general idea of the type of coast he is delineating and will, therefore, be better able to interpret the coastal features.

4. The delineator should go through quite a few photographs, studying the coastal features under a magnifying stereoscope before he commences any delineation. In so doing, he should be able to determine the position of the highwater line and, at the same time, familiarize himself with the area.

5. All items should be outlined on the photographs, using a watercolor ink that will show up clearly on the photograph. This should be done while scanning a stereo pair of photographs under a magnifying stereoscope. The choice of symbols used for outlining the different items on the photographs is left entirely to each agency.

6. The items so delineated should be transferred to the manuscript sheets. Care should be taken to insure that these items are placed on the manuscript sheets in their true orientation and horizontal position. Strict adherence to the proper manuscript symbols is essential so that any other unit or agency will have no trouble using the material.

7. A very thorough edit of the manuscript sheets should be made by trained editors to ensure that all items have been taken from the photographs and that the items are symbolized properly. The editing of this material should be done by personnel having no previous knowledge of the original interpretation and delineation.

CHAPTER VII

ILLUSTRATED PROBLEMS IN DELINEATION OF COASTAL FEATURES

The following illustrations show typical examples of the many different types of coastal areas and how each type should be delineated. The problems encountered in coastal delineation are numerous and the following illustrations are carried in this manual with the hope of aiding delineators in fulfilling their responsibility.

Fig. VII-1 is an oblique aerial photograph of a typical emergent coast–one where an offshore bar has formed and the lagoon is in the process of being filled with debris. Fig. VII-2 is a stereo-pair of vertical photographs of the area and Fig. VII-3 is the same stereo-pair on which is shown the delineation of the coastal features.

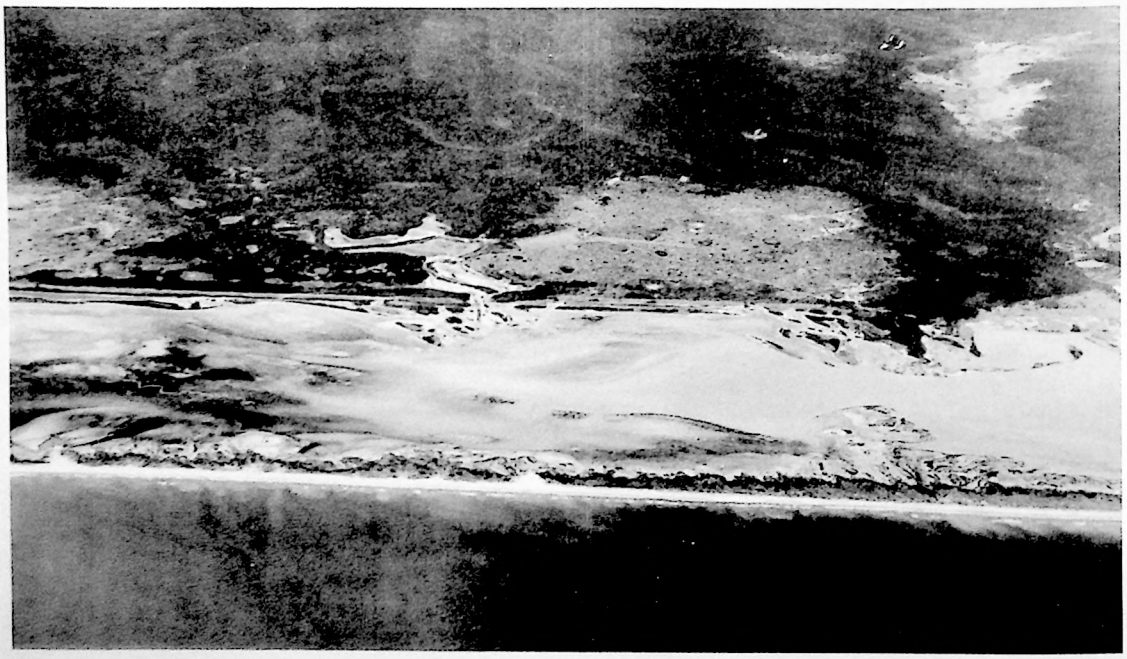


FIG. VII-1. Oblique photograph of an emergent coast.

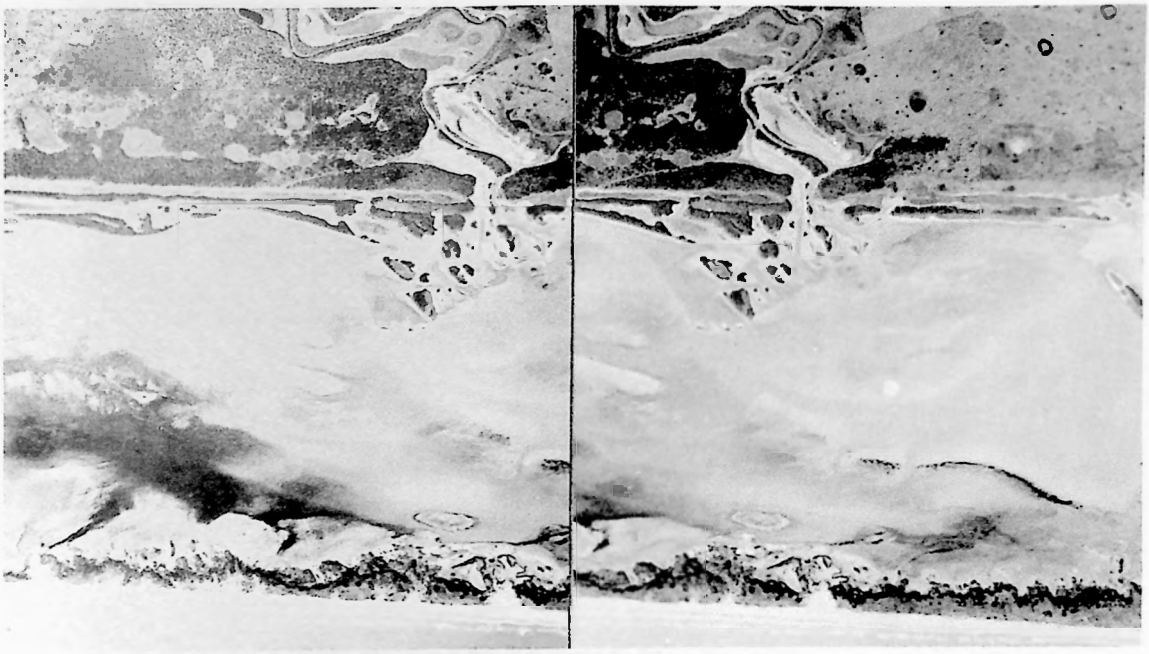


FIG. VII-2. Stereo-pair of photographs of an emergent coast.

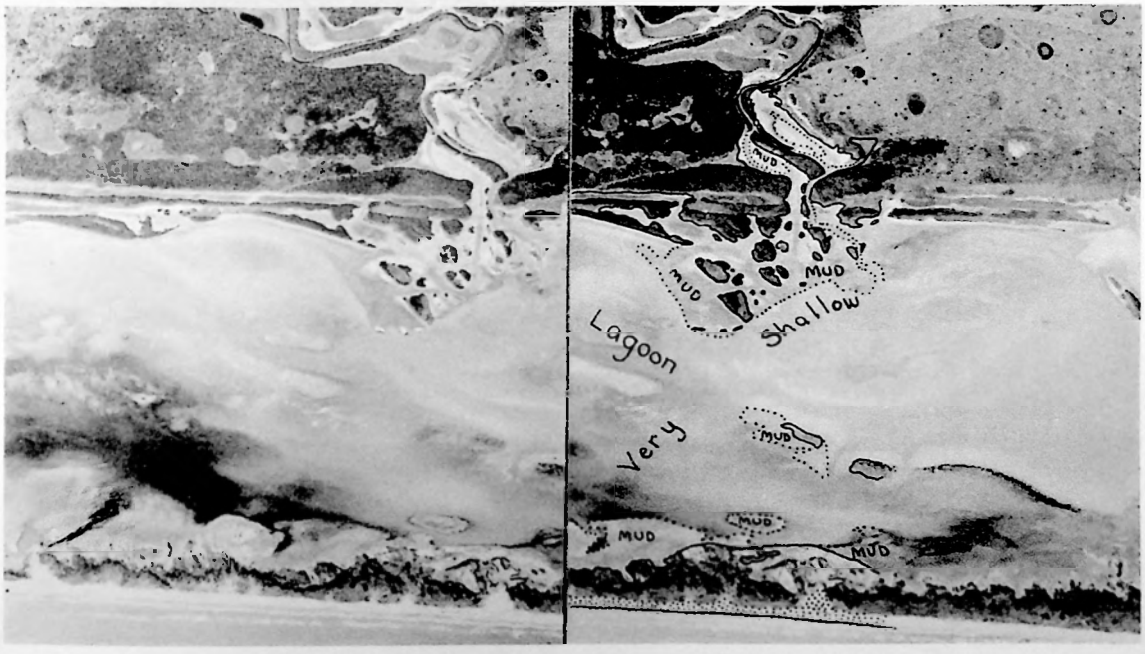


FIG. VII-3. Duplication of Fig. VII-2 showing an example of delineation of coastal features.

Fig. VII-4 is an oblique aerial photograph of a typical mature emergent coast–one where the bar has been compressed against the mainland. Note the straight even coast, the lack of bays or harbors, and the fact that there are no navigational hazards. Fig. VII-5 is a stereo-pair of vertical photographs of the area and Fig. VII-6 is the same stereo-pair on which is shown the delineation of the coastal features.

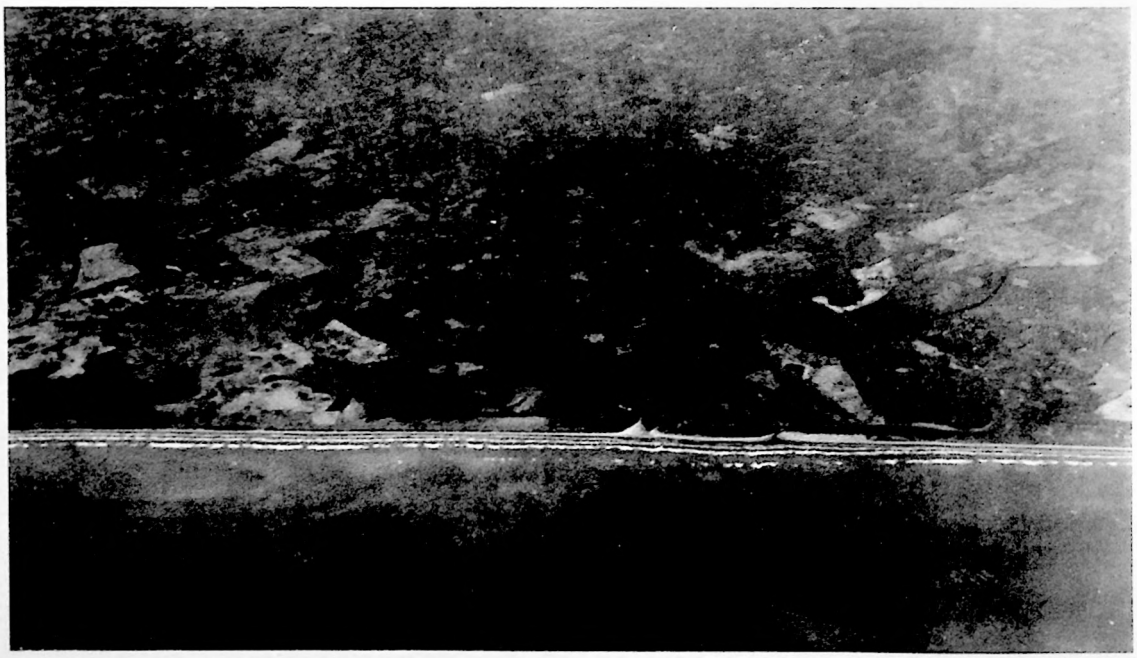


FIG. VII-4. Oblique photograph of an emergent coast.

FIG. VII-5. Stereo-pair of photographs of an emergent coast.

FIG. VII-6. Duplication of Fig. VII-5 showing an example of delineation of coastal features.

Fig. VII-7 is an oblique aerial photograph of a partially submerged coastal plain. Note the numerous small bays with baymouth and midbay bars and the general appearance of shoal water. Fig VII-8 is a stereo-pair of vertical photographs of a small portion of area covered by Fig. VII-7 and Fig. VII-9 is duplicate of Fig. VII-8 on which is shown the delineation of the coastal features.

FIG. VII-7. Oblique photograph of a partially submerged coastal plain.

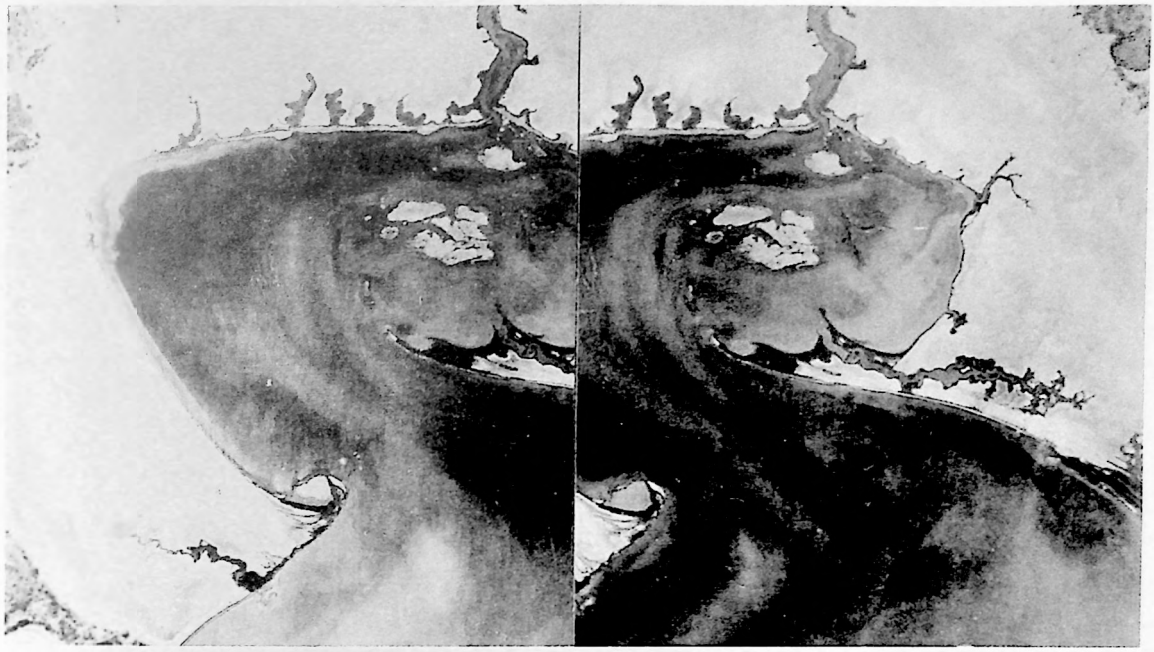


FIG. VII-8. Stereo-pair of photographs of a partially submerged coastal plain.

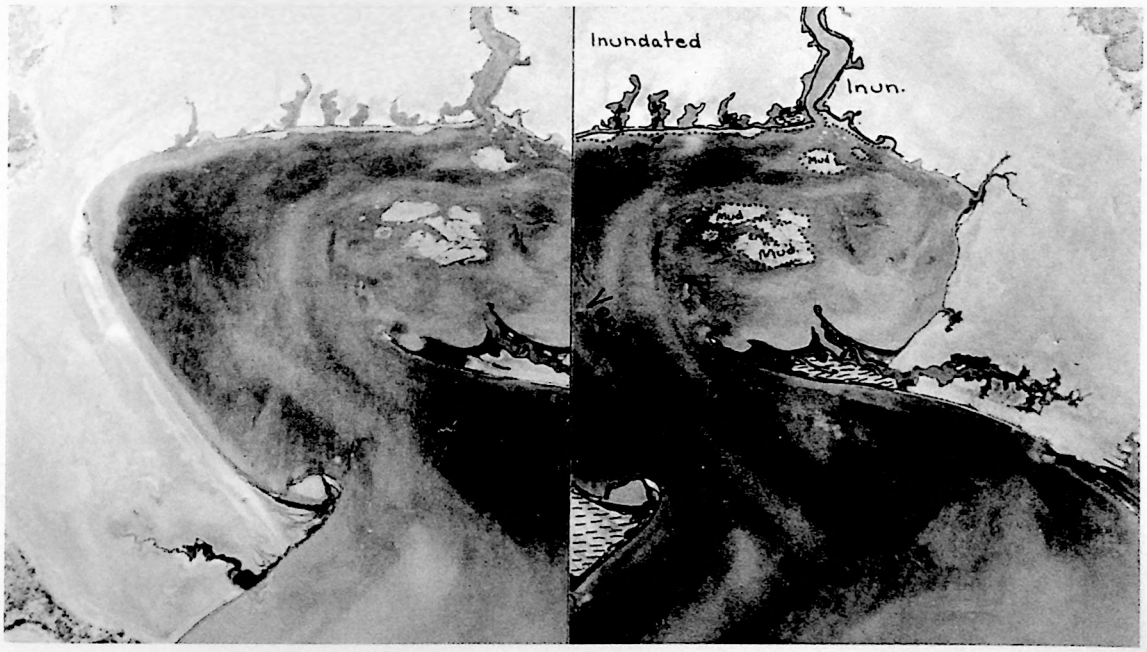


FIG. VII-9. Duplication of Fig. VII-8 showing an example of delineation of coastal features.

Fig. VII-10 is an oblique aerial photograph of a partially submerged mountainous terrain. Note the numerous bays and coves and the many islands and rocks along this type of coast. Fig. VII-11 is a stereo-pair of vertical photographs of the area and Fig. VII-12 is the same stereo-pair on which is shown the delineation of the coastal features.

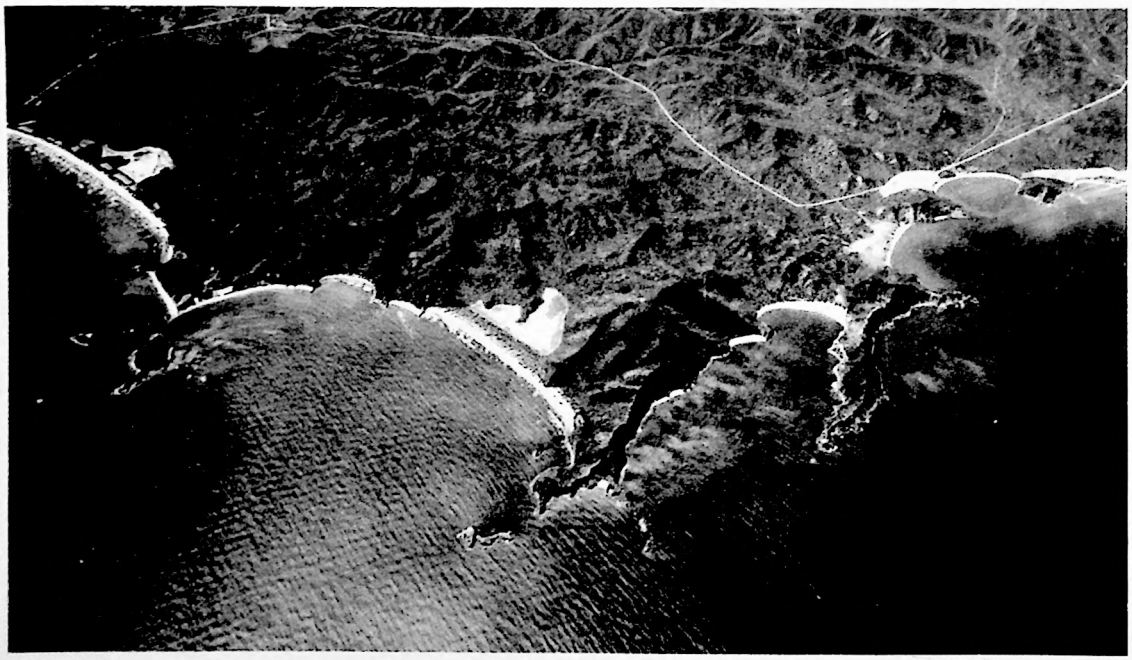


FIG. VII-10. Oblique photograph of a partially submerged mountainous terrain.

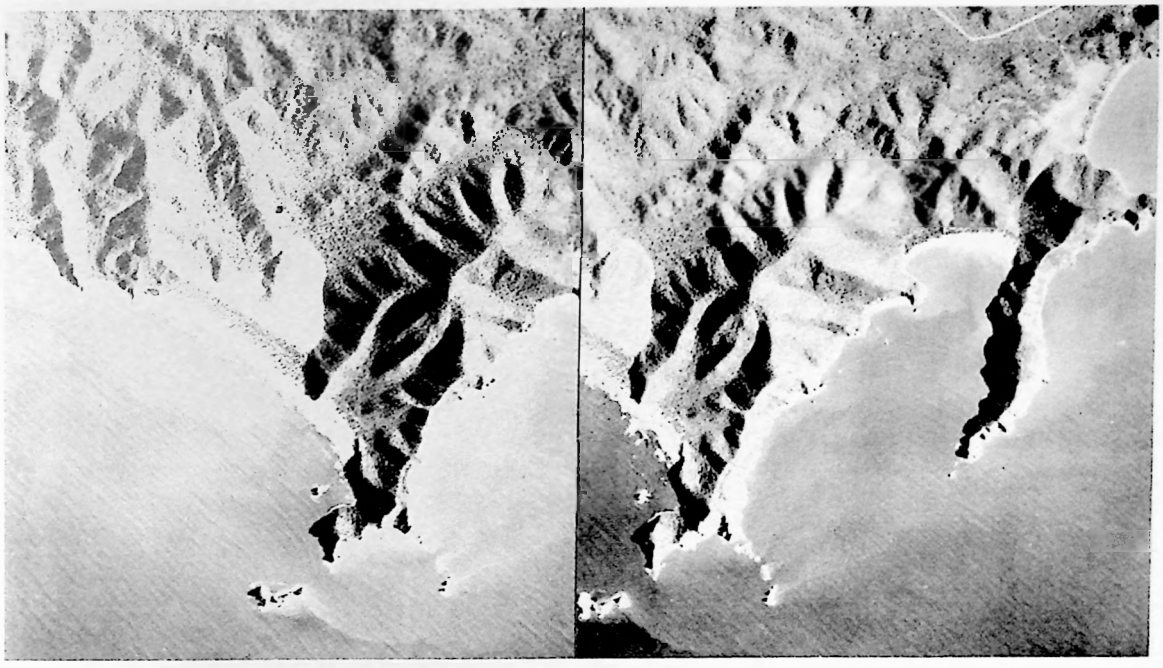


FIG. VII-11. Stereo-pair of photographs of a partially submerged mountainous terrain.

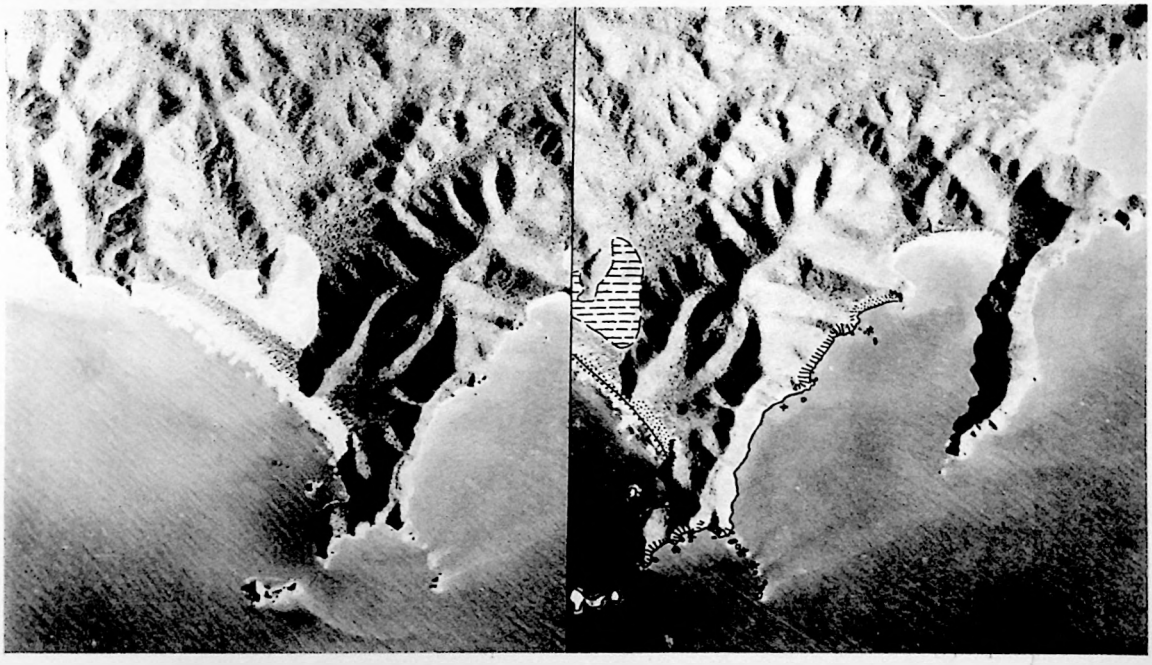


FIG. VII-12. Duplication of Fig. VII-11 showing an example of delineation of coastal features.

Fig. VII-13 is an oblique aerial photograph of a mature submergent coast–one where the peninsulas, bays, and offshore hazards have been eliminated. Note the bold marine cliff and the tone of the water which indicate deep water offshore. Fig. VII-14 is a stereo-pair of vertical photographs of the area and Fig. VII-15 is the same stereo-pair on which is shown the delineation of the coastal features.

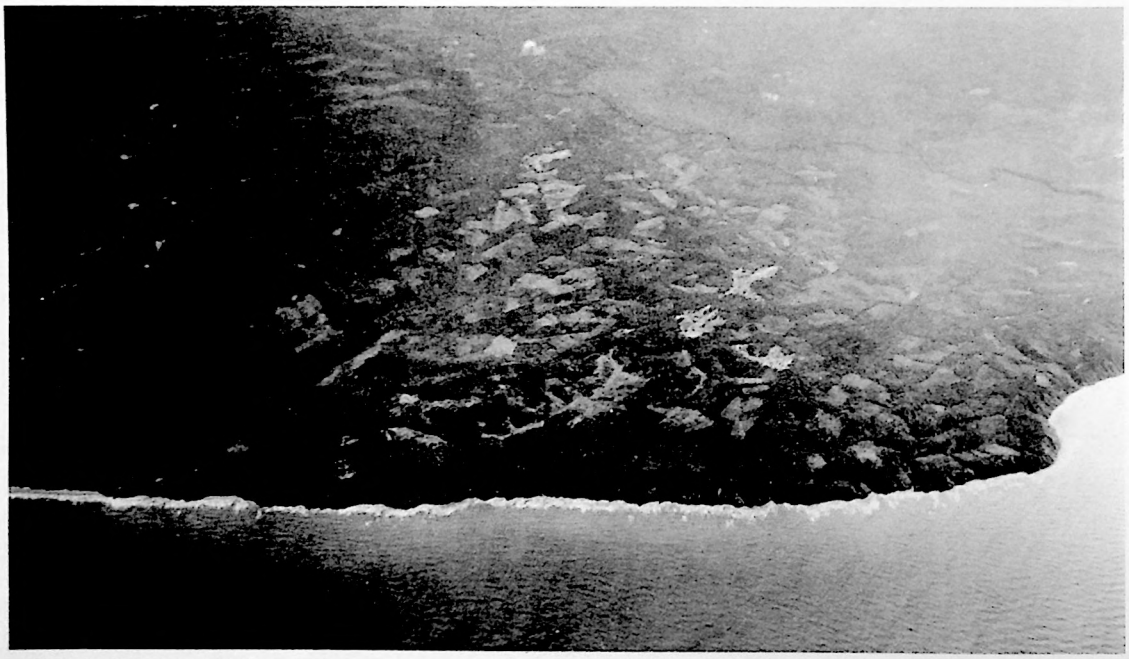


FIG. VII-13. Oblique photograph of a mature submerged coast.

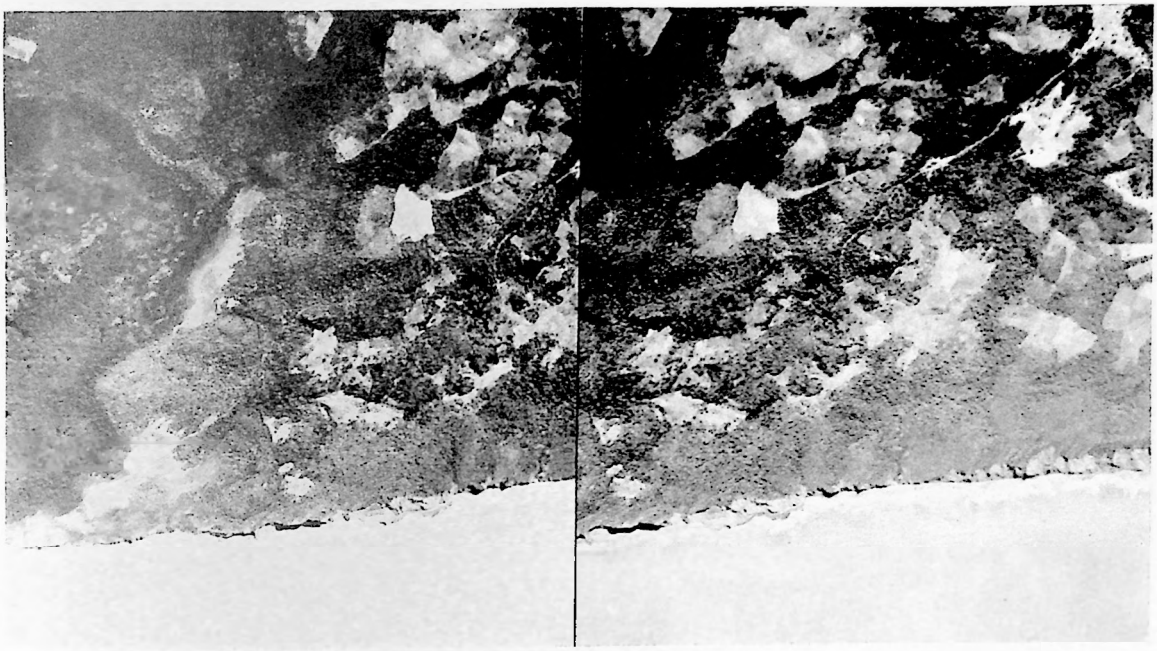


FIG. VII-14. Stereo-pair of photographs of a mature submerged coast.

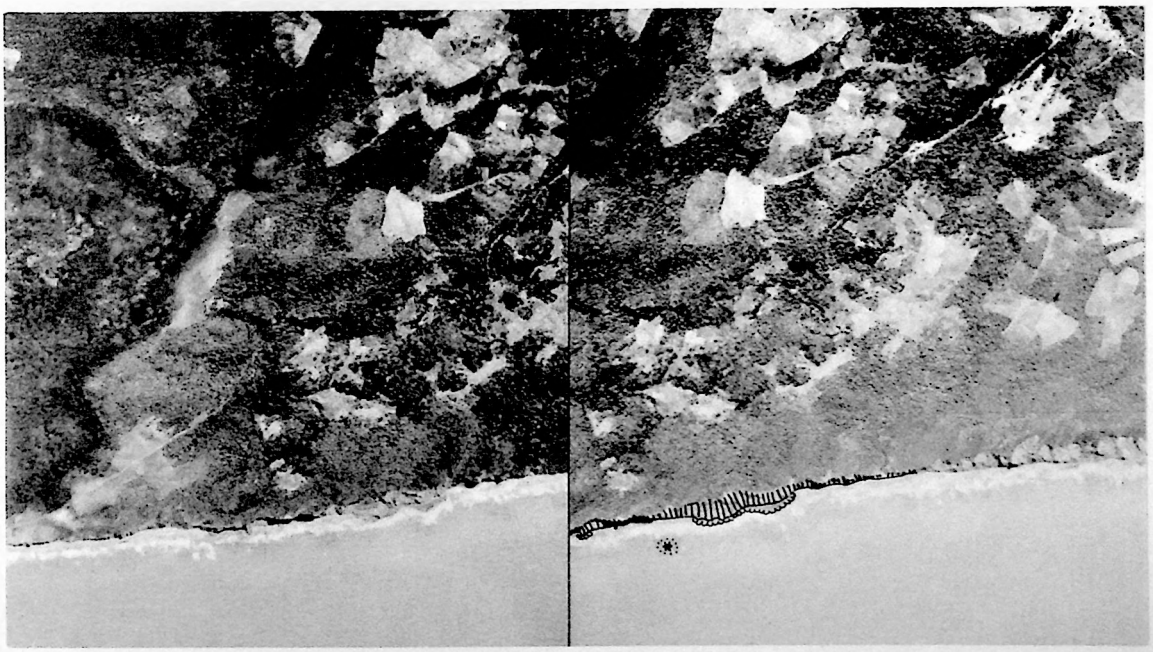


FIG. VII-15. Duplication of Fig. VII-14 showing an example of delineation of coastal features.

Fig. VII-16 is an oblique aerial photograph of a typical fiord coast. Note the numerous small icebergs which add to the delineation problem. Fig. VII-17 is a stereo-pair of vertical photographs of a portion of the area and Fig. VII-18 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-16. Oblique photograph of a typical fiord coast.

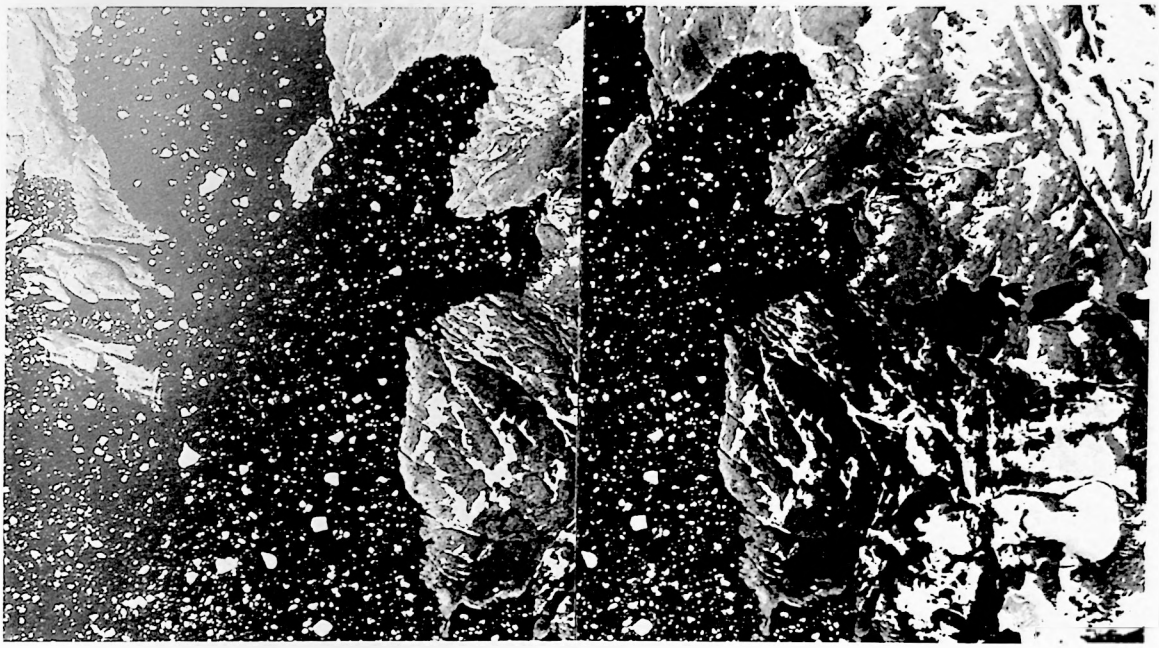


FIG. VII-17. Stereo-pair of photographs of a typical fiord coast. Note the numerous small icebergs.

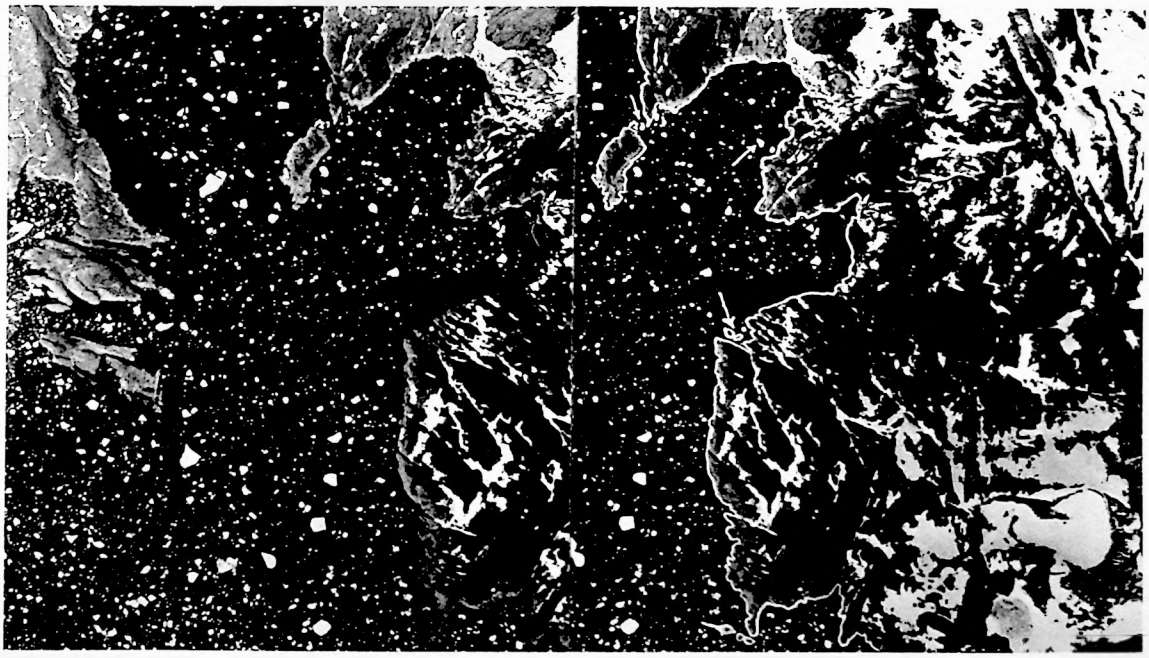


FIG. VII-18. Duplication of Fig. VII-17 showing an example of delineation of coastal features.

Fig. VII-19 is an oblique aerial photograph of a typical fiord coast. This view was taken from offshore and shows the numerous islands, islets, and rocks which are typical of this type of coast. Fig. VII-20 is a stereo-pair of vertical photographs of the area and Fig. VII-21 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-19. Oblique photograph showing the numerous islands, islets, and rocks offshore a typical fiord coast.

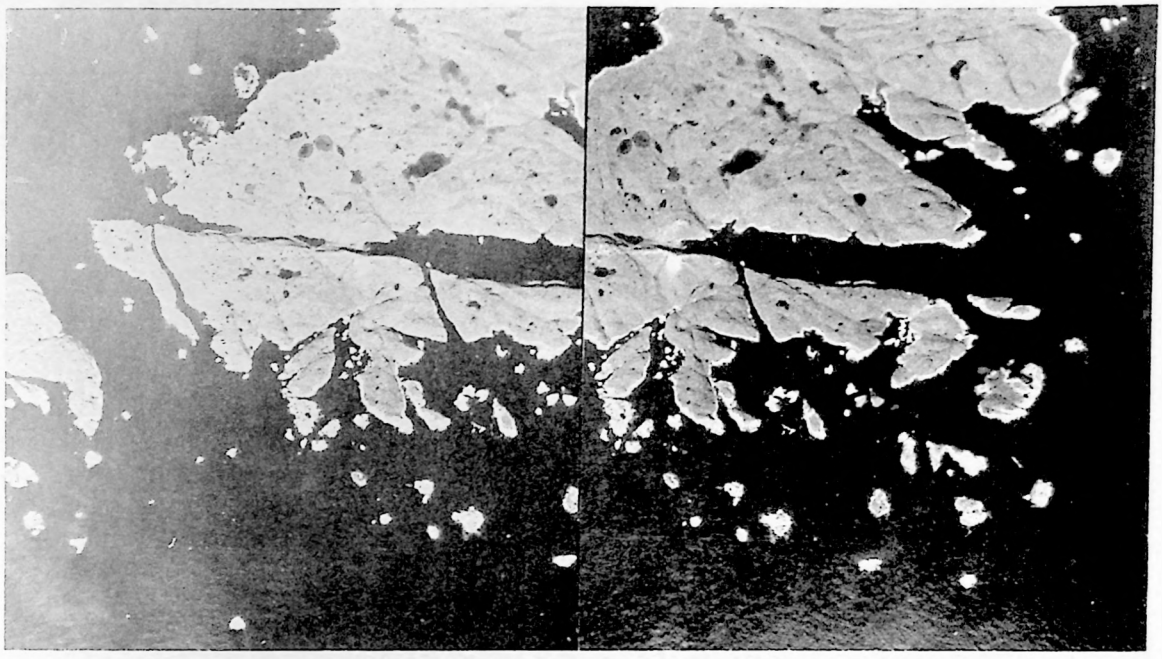


FIG. VII-20. Stereo-pair of photographs showing the numerous islands, islets, and rocks offshore a typical fiord coast.

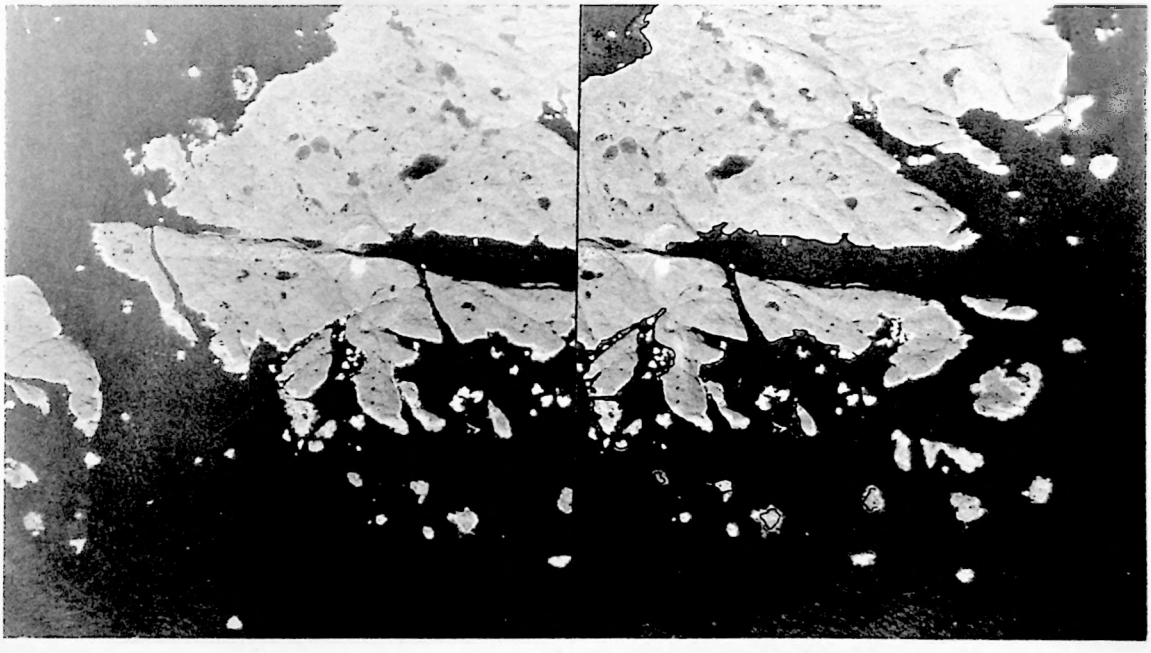


FIG. VII-21. Duplication of Fig. VII-20 showing an example of delineation of coastal features.

Fig. VII-22 is an oblique aerial photograph of a glacier at the head of a fiord. Fig. VII-23 is a stereo-pair of vertical photographs of the area and Fig. VII-24 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-22. Oblique photograph showing a glacier at the head of a fiord.

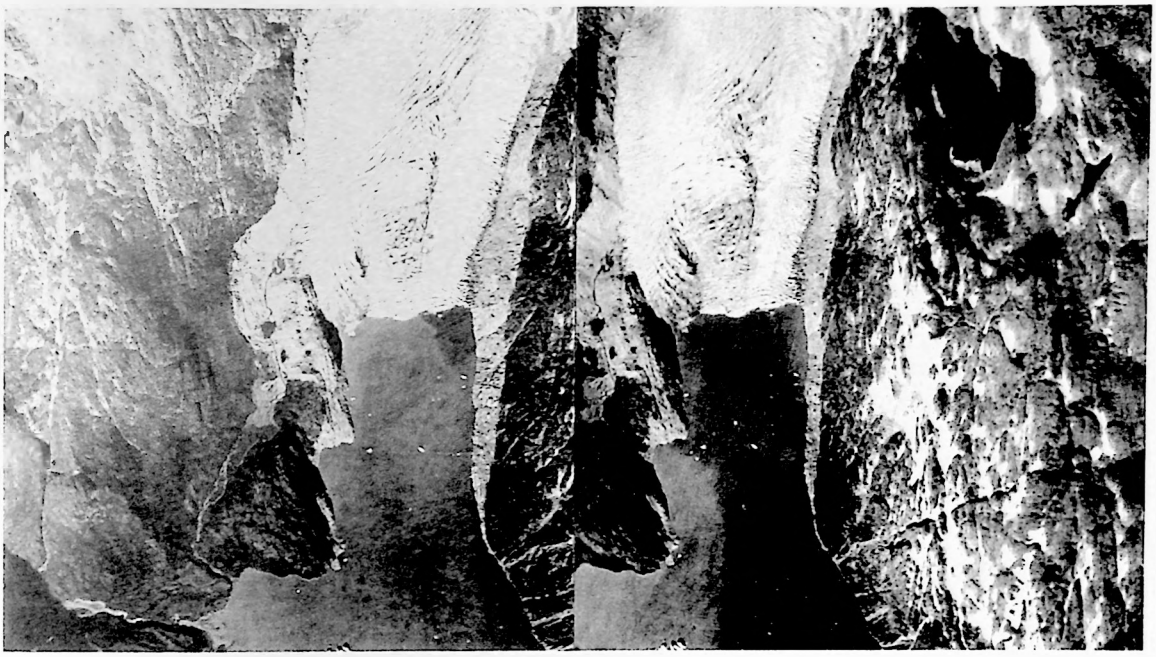


FIG. VII-23. Stereo-pair of photographs showing a glacier at the head of a fiord.

FIG. VII-24. Duplication of Fig. VII-23 showing an example of delineation of coastal features.

Fig. VII-25 is an oblique aerial photograph of a small coral atoll. Fig. VII-26 is a stereo-pair of vertical photographs of a portion of the atoll and Fig. VII-27 is the same stereo-pair on which is shown the delineation of the coastal features.

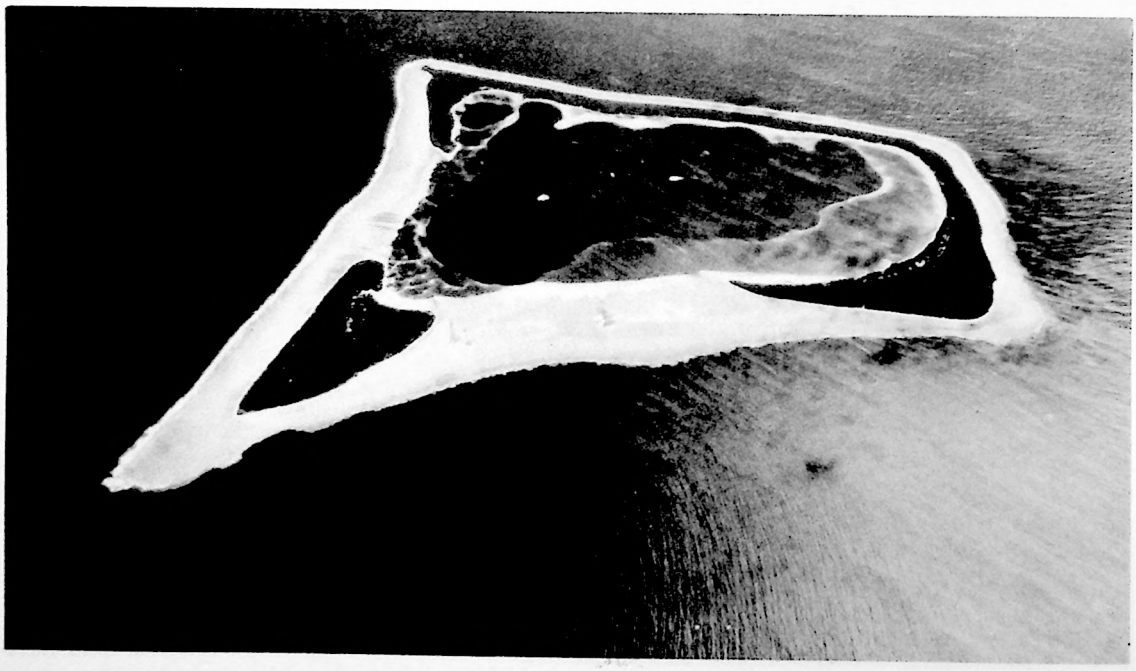


FIG. VII-25. Oblique photograph of a small coral atoll.

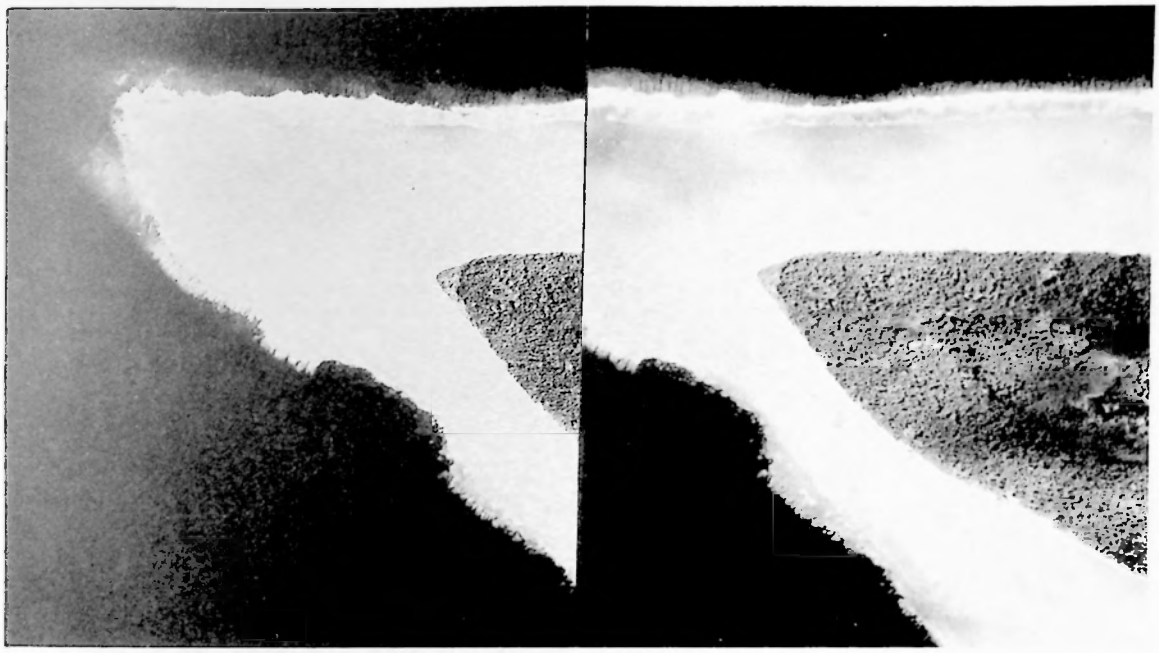


FIG. VII-26. Stereo pair of photographs of a small coral atoll.

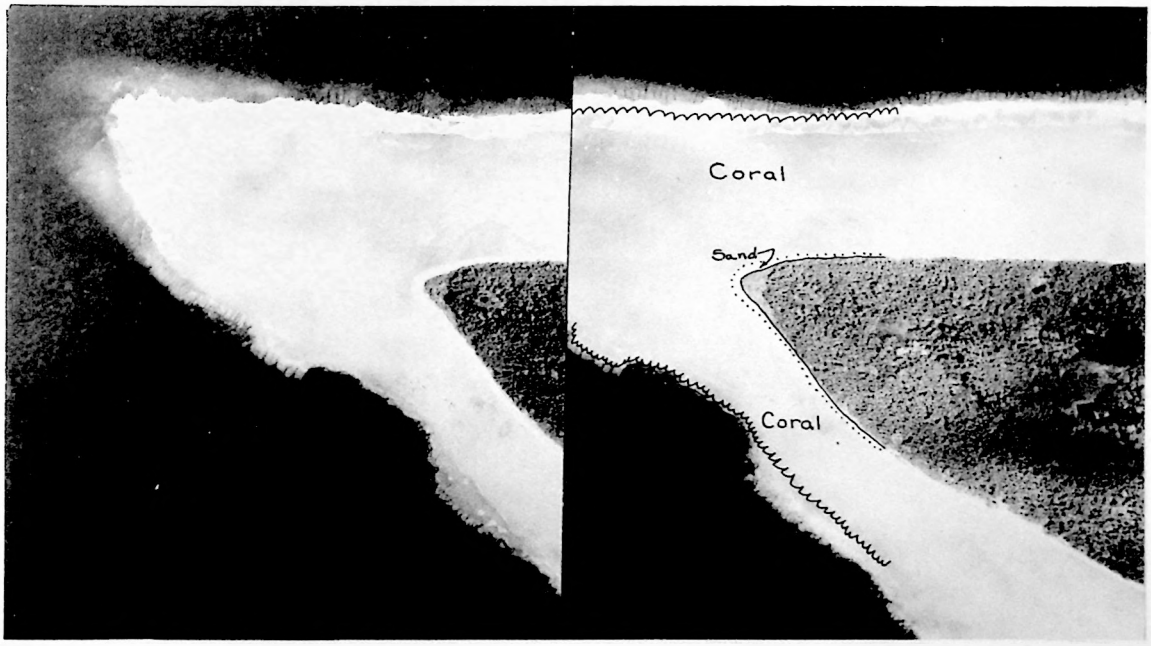


FIG. VII-27. Duplicate of Fig. VII-26 showing an example of delineation of coastal features.

Fig. VII-28 is an oblique aerial photograph of a large coral atoll and Fig. VII-29 is a stereo-pair of vertical photographs of a portion of the atoll. Note the passageway into the lagoon and a few coral "pillars" within the lagoon. Fig. VII-30 is the same stereo-pair as Fig. VII-29 on which is shown the delineation of the coastal features.

FIG. VII-28. Oblique photograph of a large coral atoll.

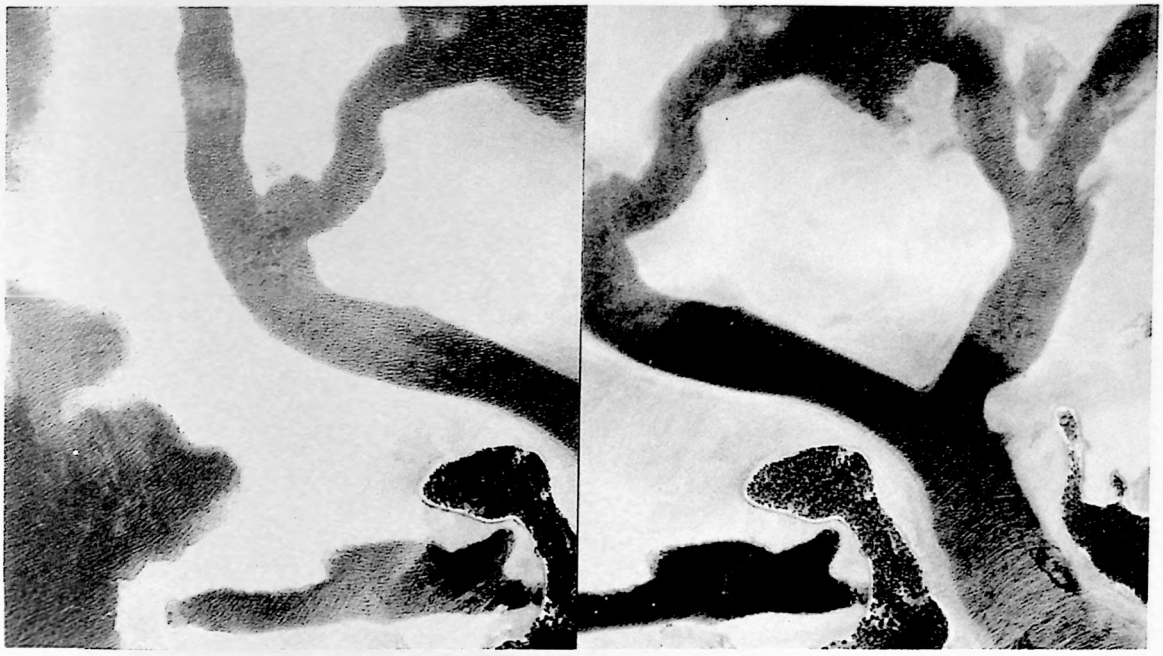


FIG. VII-29. Stereo-pair of photographs of a large coral atoll.

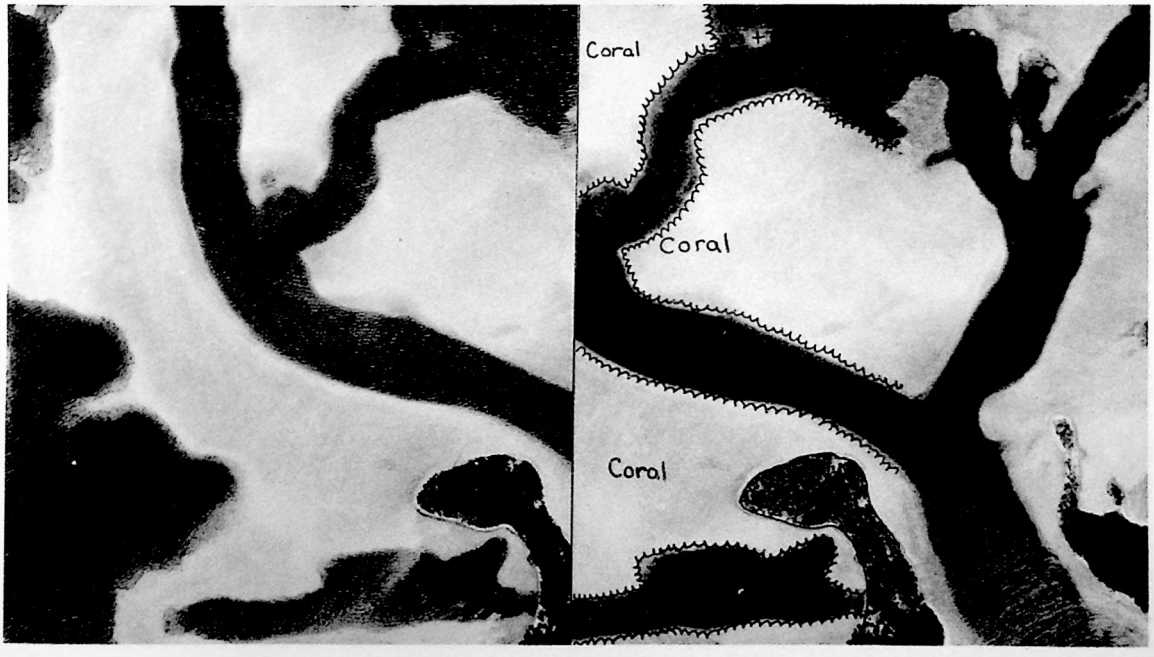


FIG. VII-30. Duplicate of Fig. VII-29 showing an example of delineation of coastal features.

Fig. VII-31 is an oblique aerial photograph of one type of river delta. Note the numerous mud and sand banks some of which are above high water level, some above low water level and some submerged at all times. This type of area is very difficult to delineate properly. Fig. VII-32 is a stereo-pair of vertical photographs of the area and Fig. VII-33 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-31. Oblique photograph of a typical river delta.

FIG. VII-32. Stereo pair of photographs of a typical river delta.

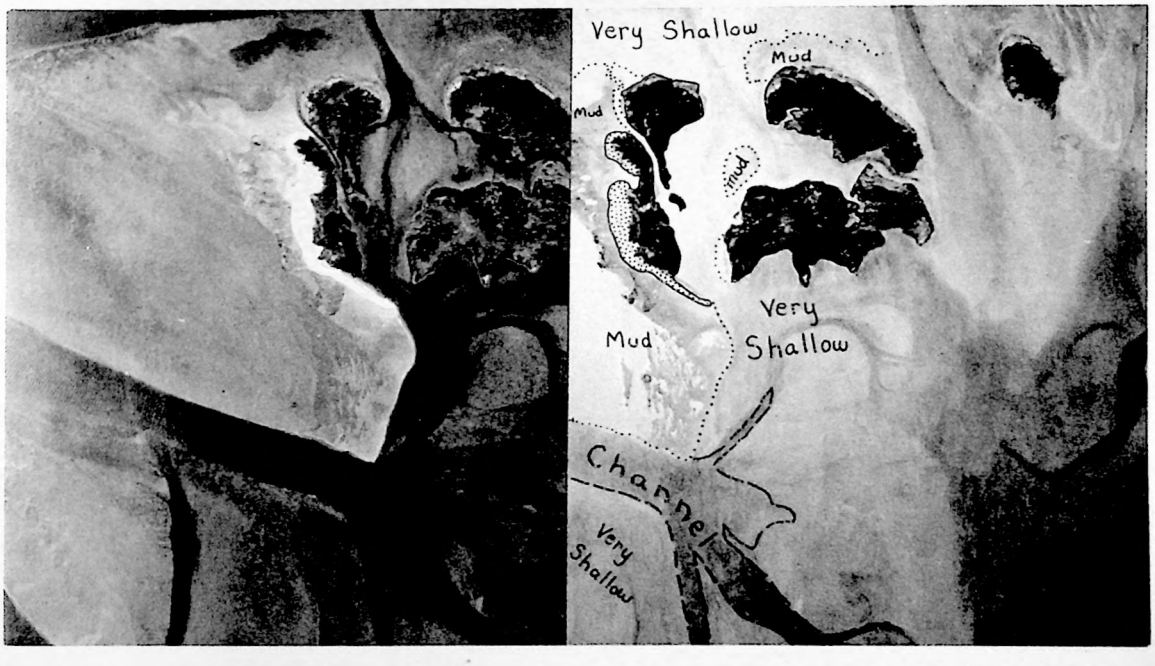


FIG. VII-33. Duplicate of Fig. VII-32 showing an example of delineation of coastal features.

Fig. VII-34 is an oblique aerial photograph of another type of river delta. The delta in this case is quite extensive and the mud is covered with mangrove. Fig. VII-35 is a stereo-pair of vertical photographs of a portion of the area and Fig. VII-36 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-34. Oblique photograph of a typical river delta.

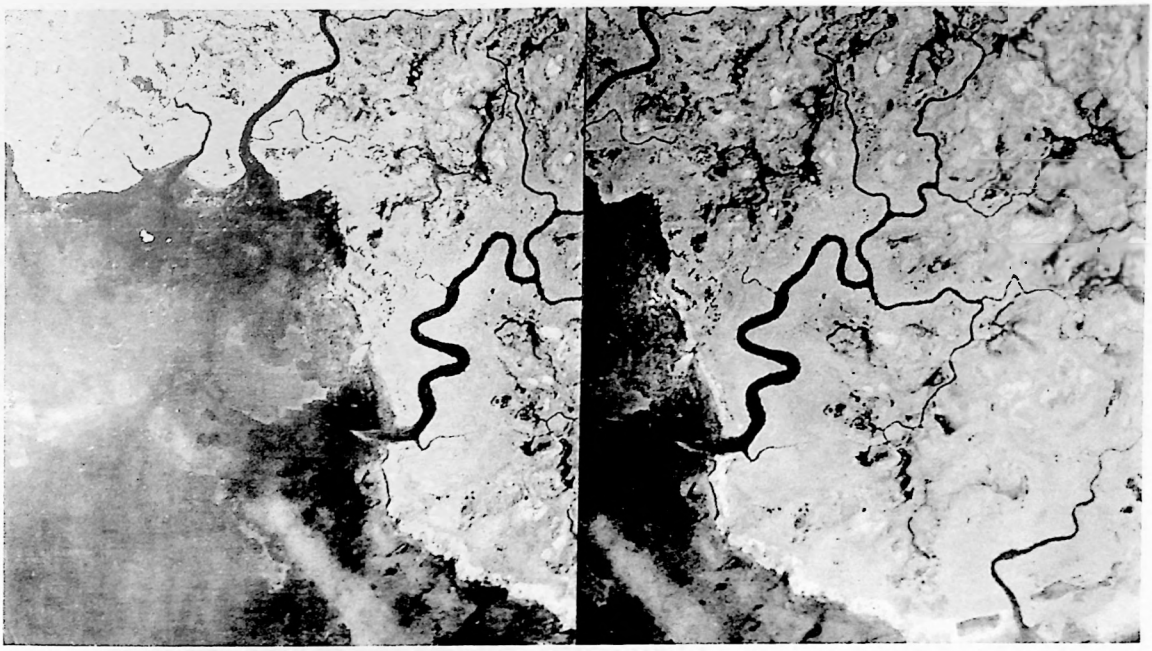


FIG. VII-35. Stereo-pair of photographs of a typical river delta.

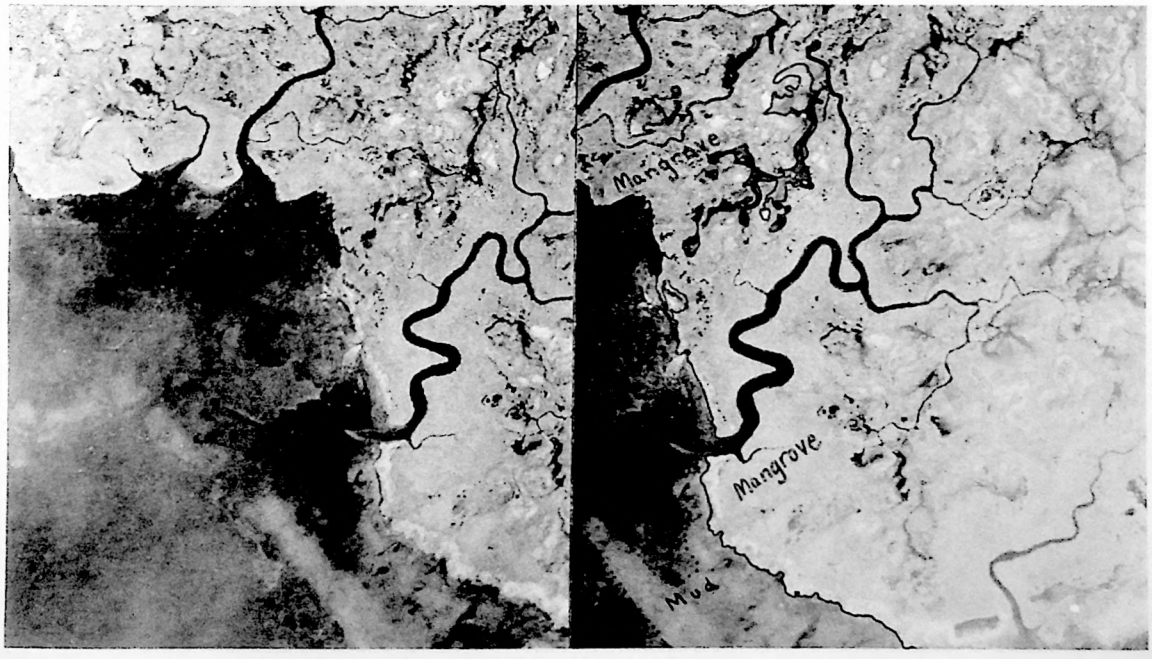


FIG. VII-36. Duplicate of Fig. VII-35 showing an example of delineation of coastal features.

Fig. VII-37 is an oblique aerial photograph of another type of river delta. This delta is quite extensive in areas with mangrove growing along the shoreline and along the streams. Large extensive areas in back of the mangrove are subject to inundation. Fig. VII-38 is a stereo-pair of vertical photographs of a portion of the area and Fig. VII-39 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-37. Oblique photograph of a typical river delta.

FIG. VII-38. Stereo-pair of photographs of a typical river delta.

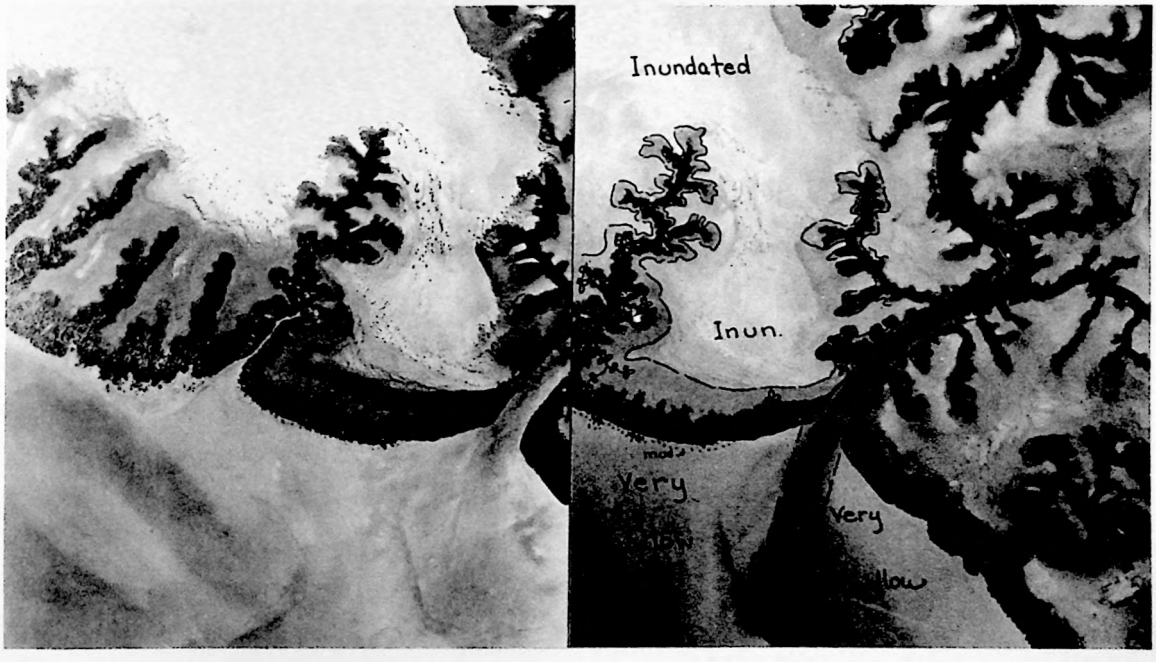


FIG. VII-39. Duplicate of Fig. VII-38 showing an example of delineation of coastal features.

Fig. VII-40 is an oblique aerial photograph of a small lobate delta. This is another type of delta which is very difficult to delineate properly on an aerial photograph. Fig. VII-41 is a stereo-pair of vertical photographs of a portion of the area and Fig. VII-42 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-40. Oblique photograph of a typical river delta.

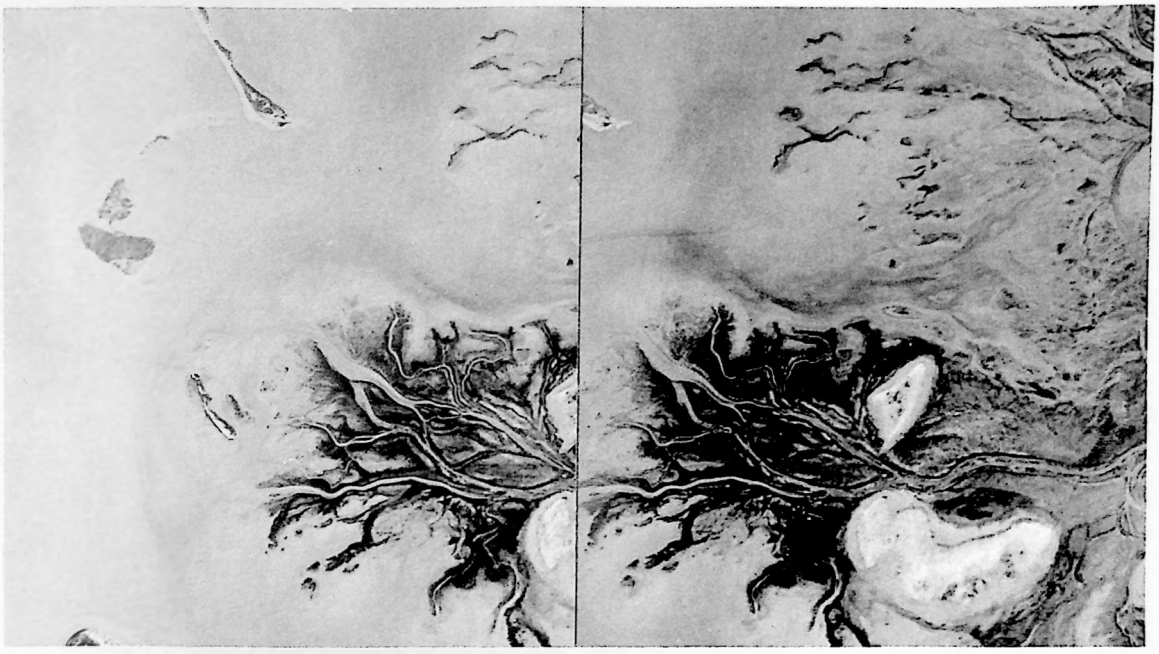


FIG. VII-41. Stereo-pair of photographs of a typical river delta.

FIG. VII-42. Duplicate of Fig. VII-41 showing an example of delineation of coastal features.

Fig. VII-43 is an oblique aerial photograph of a small cuspate delta. This type of delta is not quite as difficult to delineate as those previously discussed. Fig. VII-44 is a stereo-pair of vertical photographs of the area and Fig. VII-45 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-43. Oblique photograph of a typical river delta.

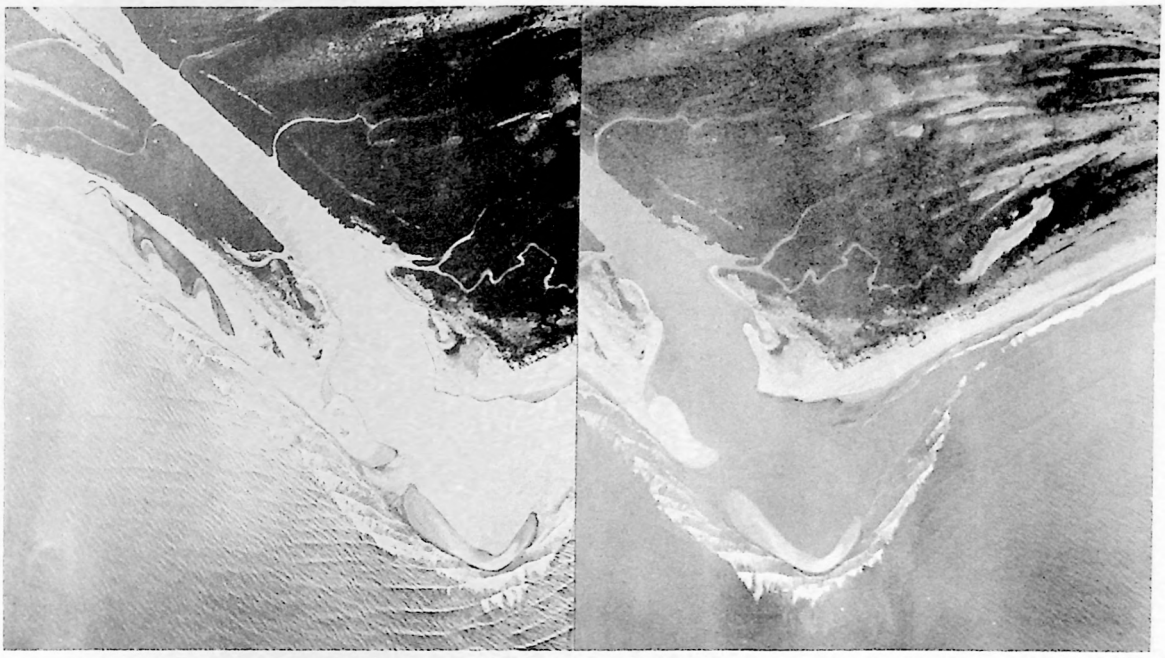


FIG. VII-44. Stereo pair of photographs of a typical river delta.

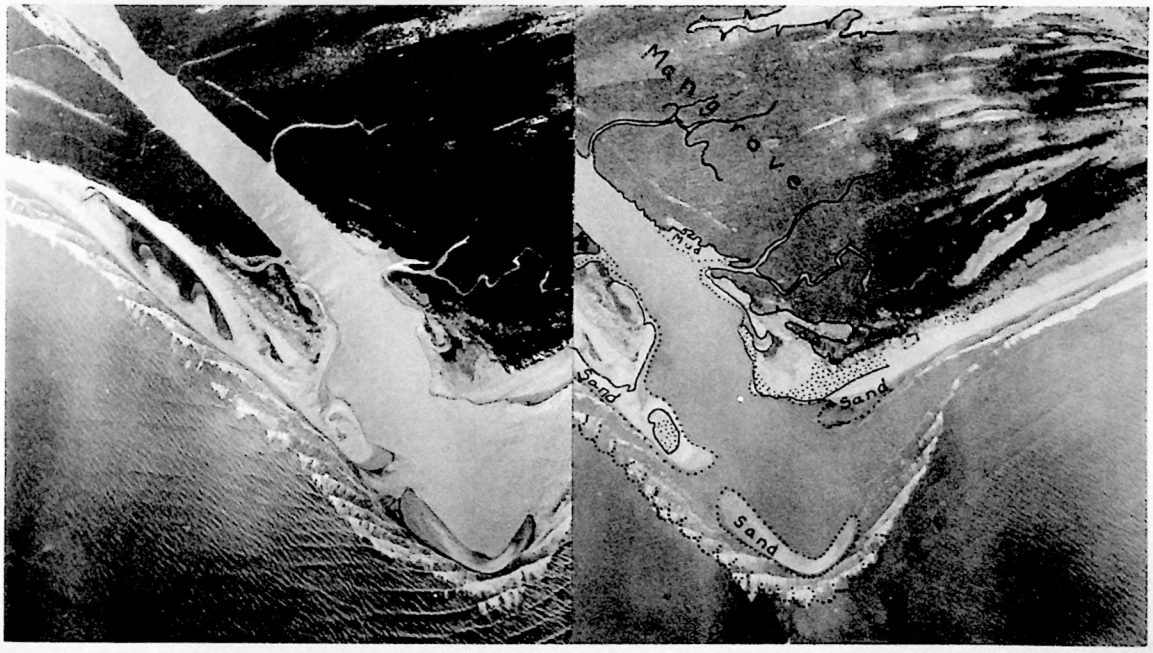


FIG. VII-45. Duplicate of Fig. VII-44 showing an example of delineation of coastal features.

Fig. VII-46 is an oblique aerial photograph of a small arcuate delta. This type of delta may be quite simple to delineate. On the other hand, it may be quite difficult to delineate depending on the amount of silt being brought to the sea. Fig. VII-47 is a stereo-pair of vertical photographs of the area and Fig. VII-48 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-46. Oblique photograph of a typical river delta.

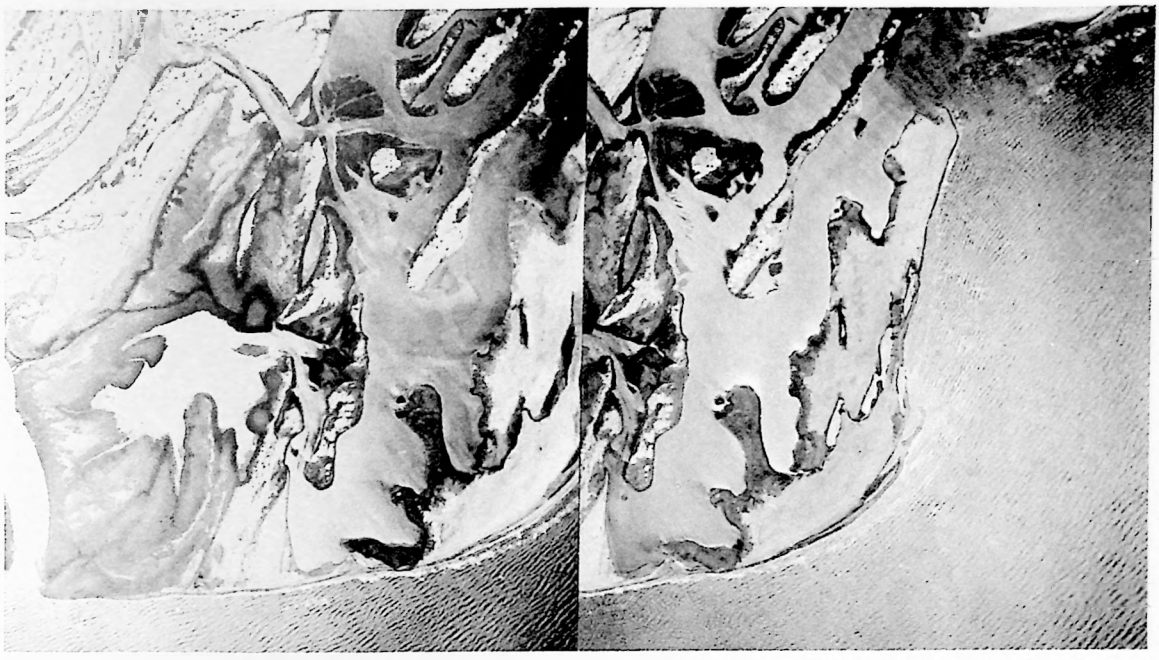


FIG. VII-47. Stereo-pair of photographs of a typical river delta.

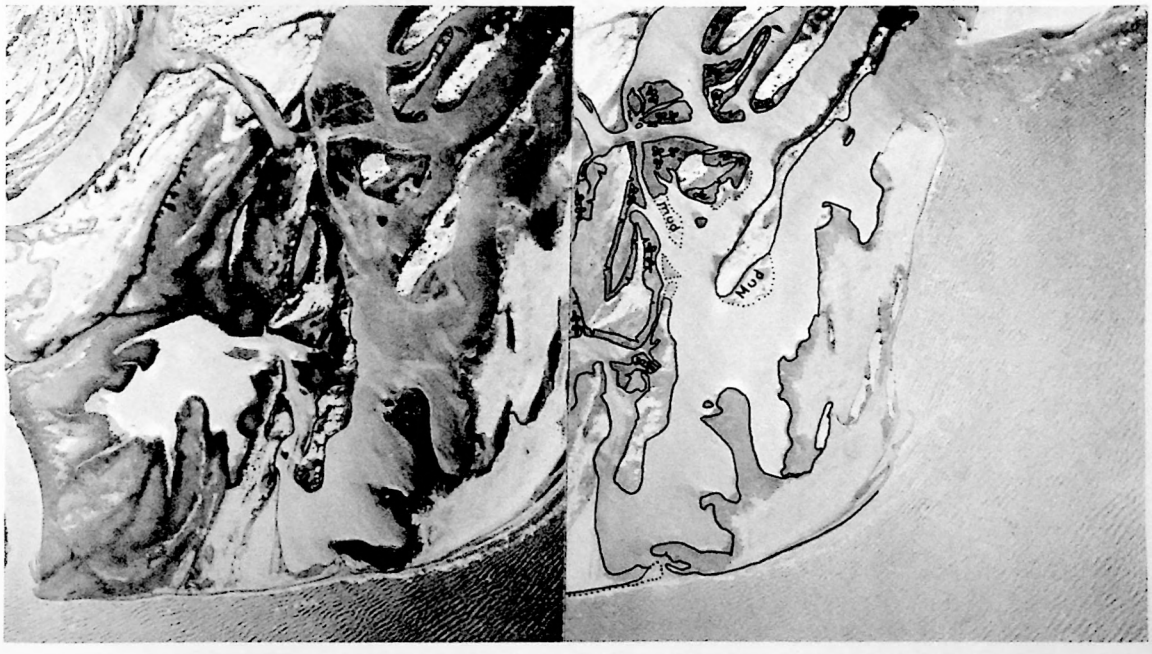


FIG. VII-48. Duplicate of Fig. VII-47 showing an example of delineation of coastal features.

Fig. VII-49 is an oblique aerial photograph of another typical form of river delta Note the mangrove and salt pans along the coast. Fig. VII-50 is a stereo-pair of vertical photographs of a portion of the area and Fig. VII-51 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-49. Oblique photograph of a typical river delta.

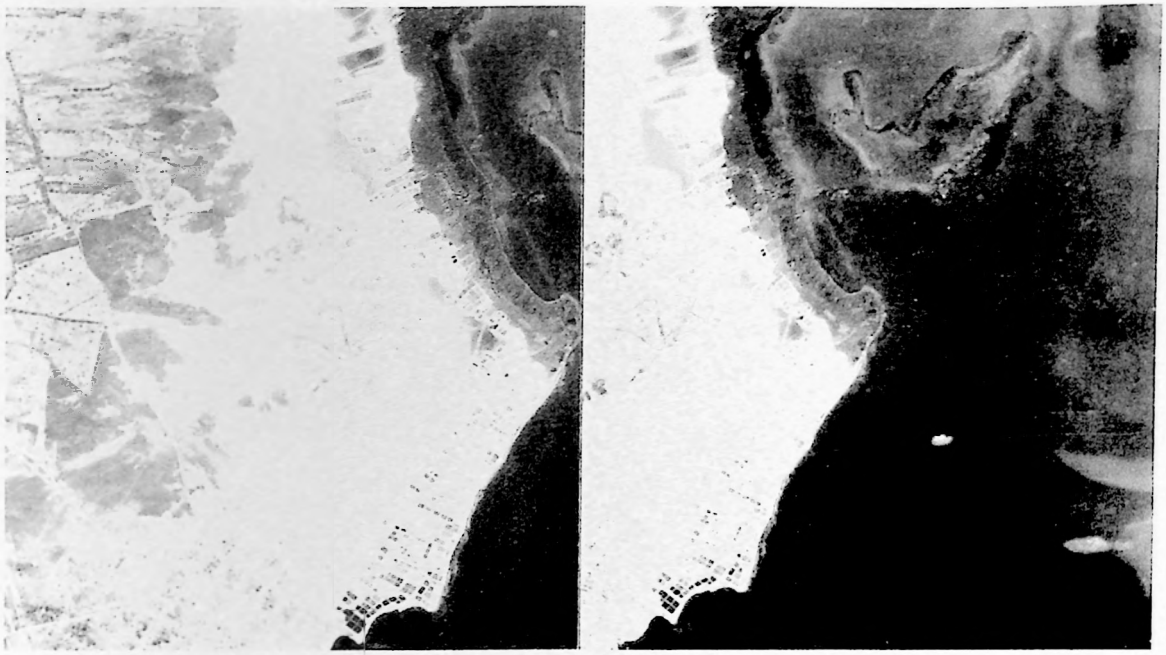


FIG. VII-50. Stereo pair of photographs of a typical river delta. Note the salt pans.

FIG. VII-51. Duplicate of Fig. VII-50 showing an example of delineation of coastal features.

Fig. VII-52 is an oblique aerial photograph of an alluvial plain. This type of coast is usually quite simple to delineate and the water offshore is generally quite deep. Fig. VII-53 is a stereo-pair of vertical photographs of the area and Fig. VII-54 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-52. Oblique photograph of an alluvial plain.

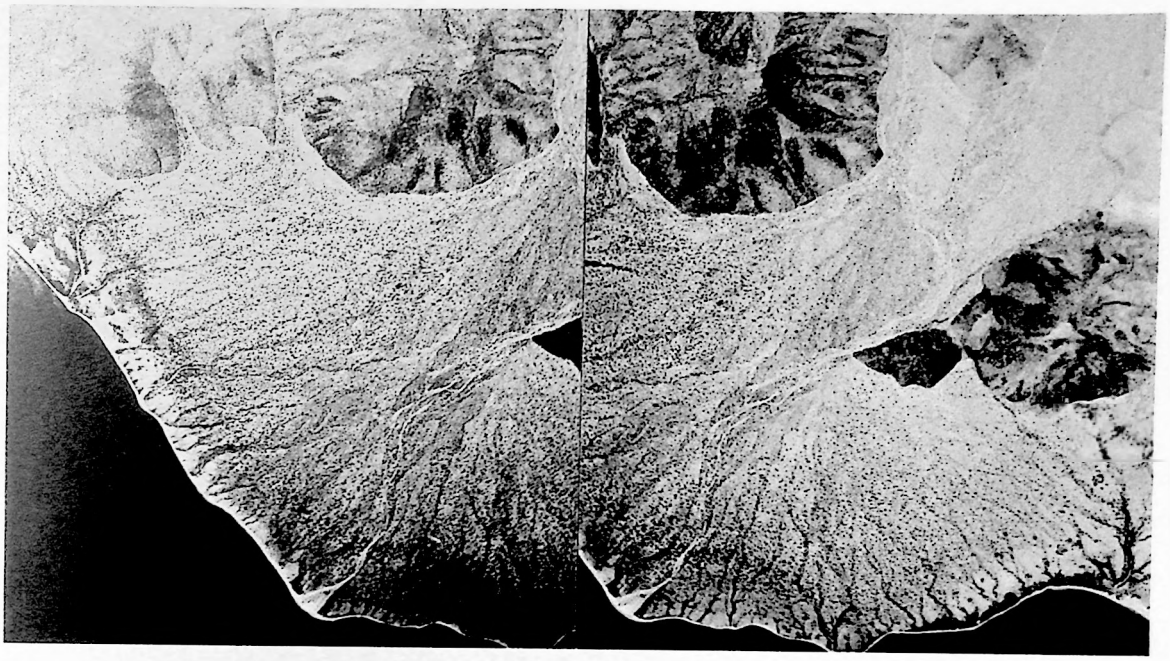


FIG. VII-53. Stereo-pair of photographs of an alluvial plain.

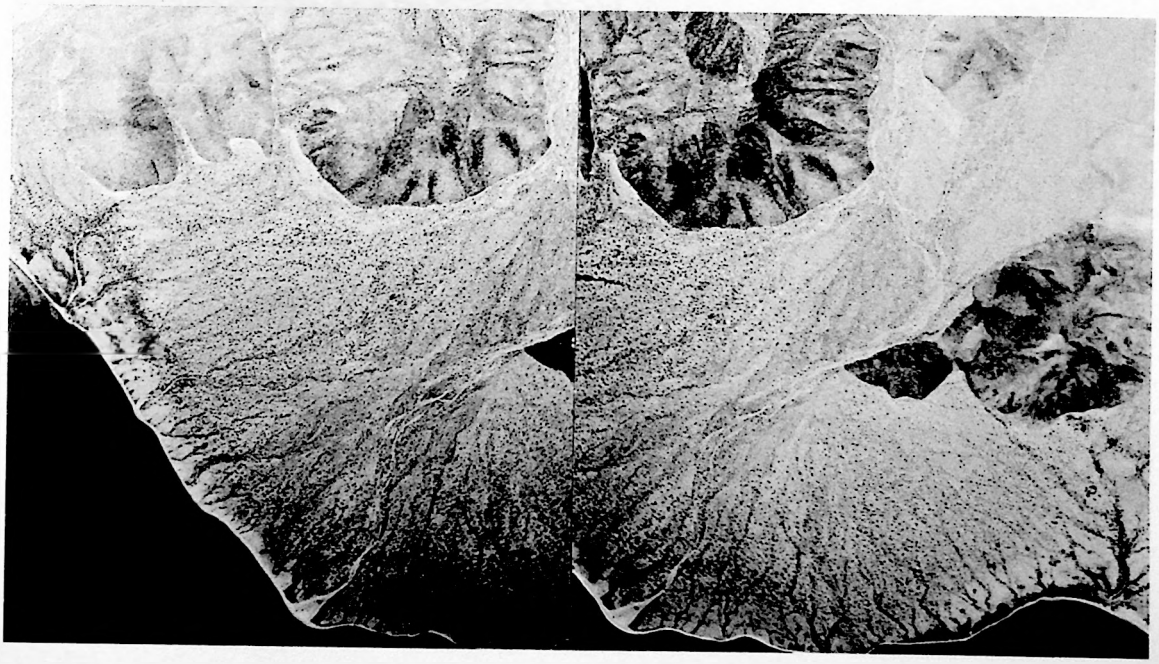


FIG. VII-54. Duplicate of Fig. VII-53 showing an example of delineation of coastal features.

Fig. VII-55 is an oblique aerial photograph of an outwash plain in a typical fiord area. This type of area is usually quite difficult to delineate similar to river deltas. Fig. VII-56 is a stereo-pair of vertical photographs of the area and Fig. VII-57 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-55. Oblique photograph of an outwash plain.

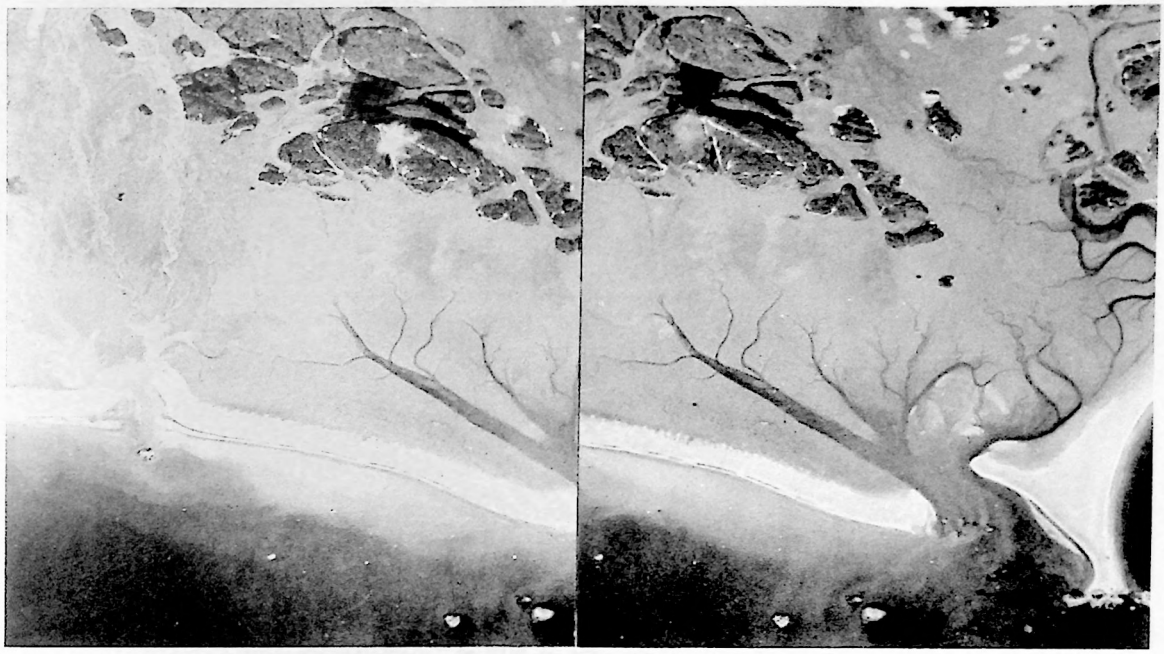


FIG. VII-56. Stereo-pair of photographs of an outwash plain.

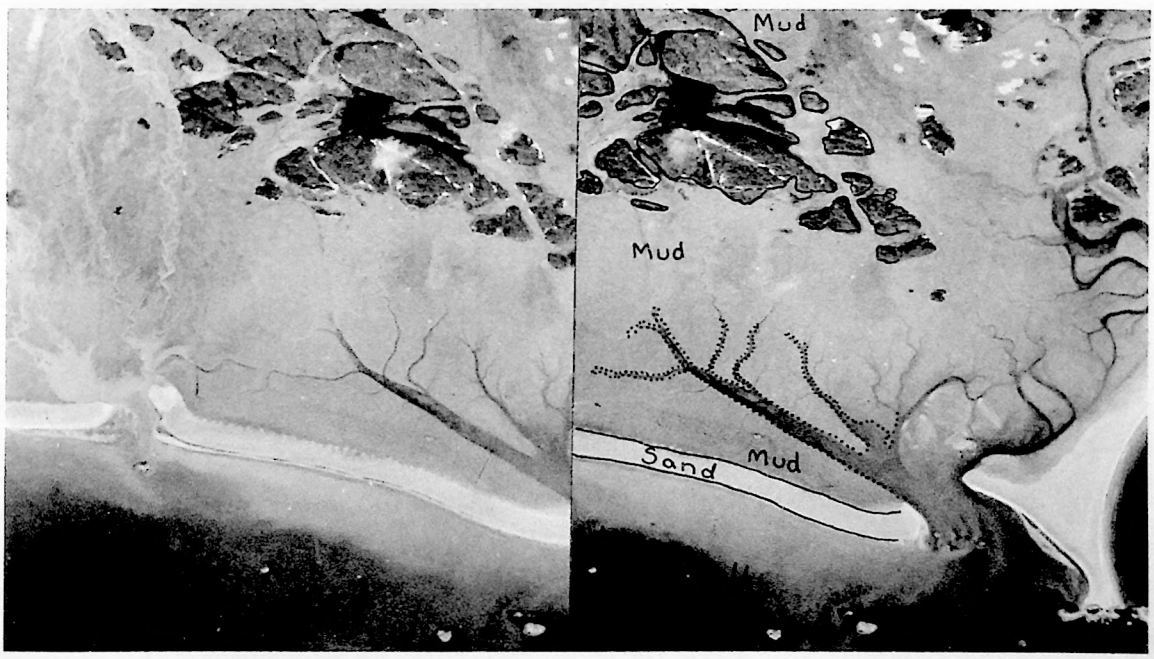


FIG. VII-57. Duplicate of Fig. VII-56 showing an example of delineation of coastal features.

Fig. VII-58 is an oblique aerial photograph of a small volcanic island. This type of area is usually not to difficult to delineate and the water is generally very deep offshore. Fig. VII-59 is a stereo-pair of vertical photographs of the area and Fig. VII-60 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-58. Oblique photograph of a typical volcanic island.

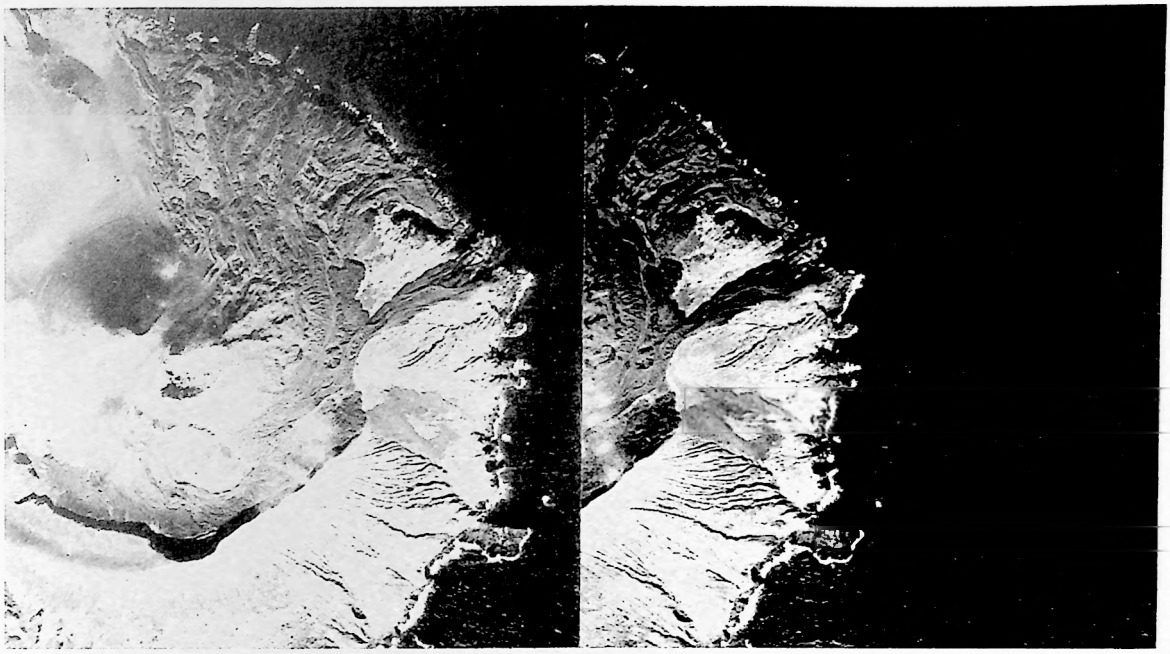


FIG. VII-59. Stereo-pair of photographs of a typical volcanic island.

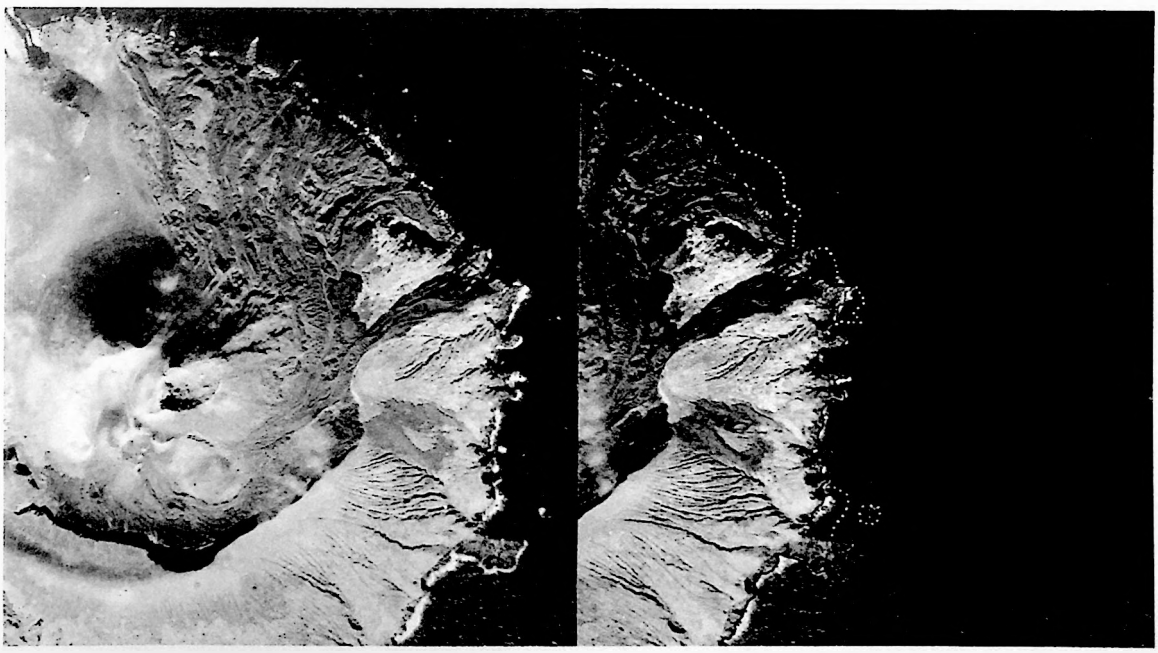


FIG. VII-60. Duplicate of Fig. VII-59 showing an example of delineation of coastal features.

Fig. VII-61 is an oblique aerial photograph of a spit and a tombolo. Fig. VII-62 is a stereo-pair of vertical photographs of the area and Fig. VII-63 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-61 Oblique photograph of a typical spit and a tombolo.

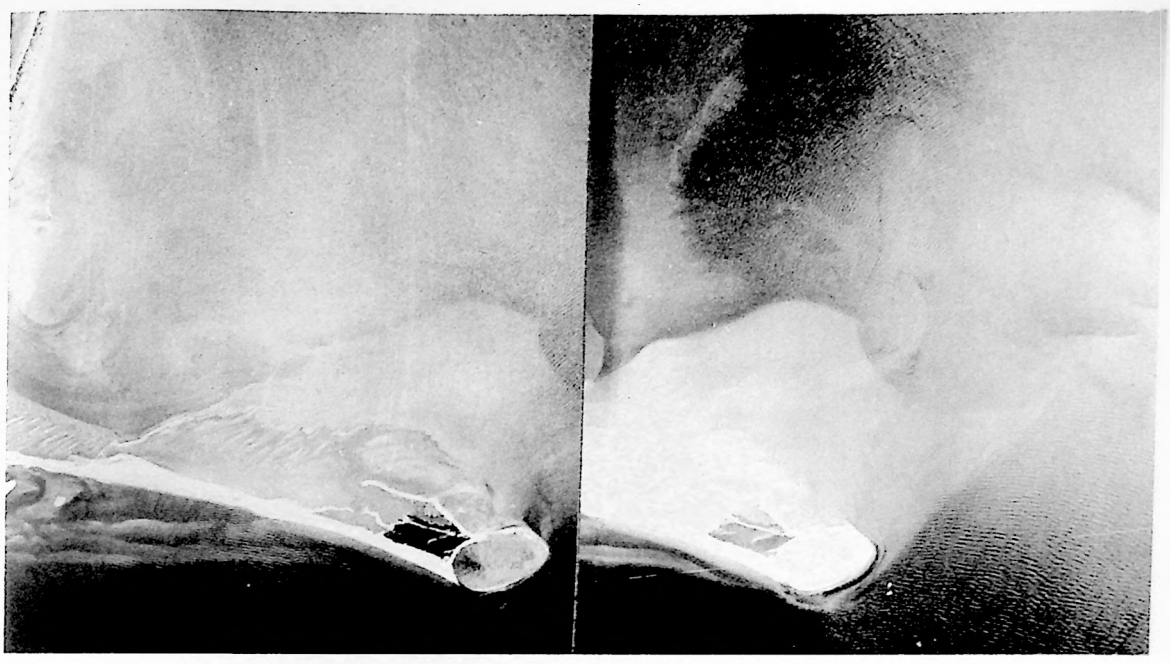


FIG. VII-62. Stereo-pair of photographs of a typical spit and a tombolo.

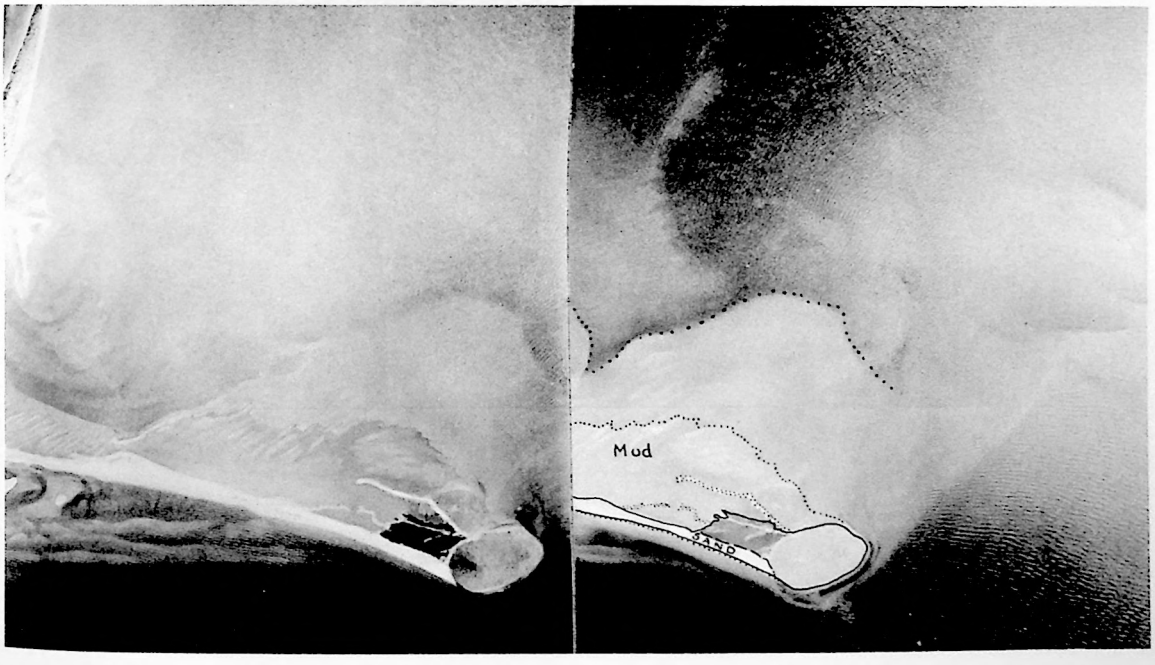


FIG. VII-63. Duplicate of Fig. VII-62 showing an example of delineation of coastal features.

Fig. VII-64 is an oblique aerial photograph of a typical compound spit. The water between this type of spit and the main coast is usually shallow with numerous bars and submerged mud banks. Fig. VII-65 is a stereo-pair of vertical photographs of a portion of the area and Fig. VII-66 is the same stereo-pair on which is shown the delineation of the coastal features.

FIG. VII-64. Oblique photograph of a compound spit.

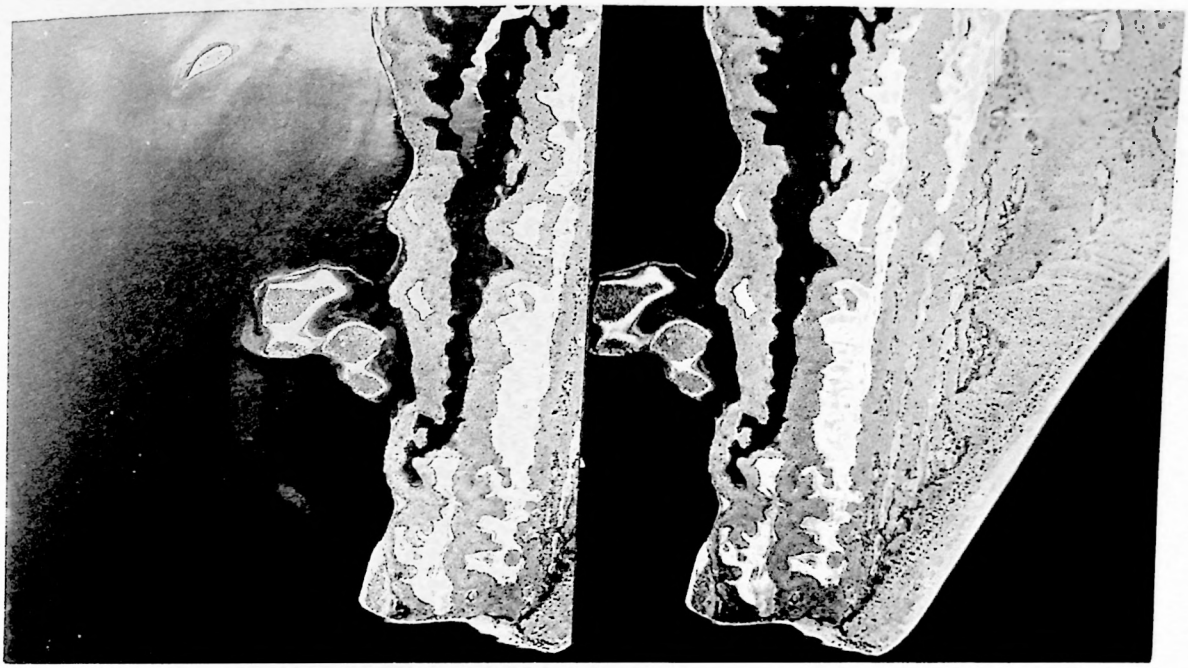


FIG. VII-65. Stereo pair of photographs of a compound spit.

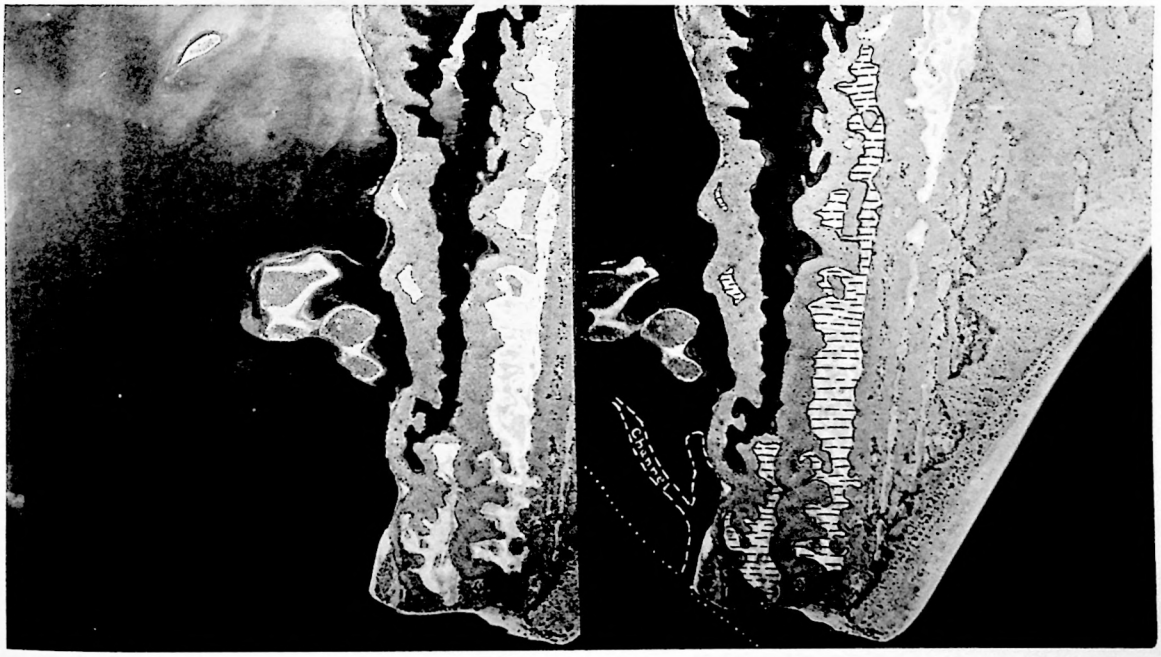


FIG. VII-66. Duplicate of Fig. VII-65 showing an example of delineation of coastal features.

Fig. VII-67 is an oblique aerial photograph of compound coast-submergence followed by a slight emergence. This type of coast is similar to a river delta. This is especially true in areas which are protected from wave action. Along outside coastal areas, this type of coast is similar to any other emergent coast. Fig. VII-68 is a stereo-pair of vertical photographs of a portion of the area and Fig. VII-69 is the same stereo-pair on which is shown the delineation of coastal features.

FIG. VII-67. Oblique photograph of a compound coast (submergence followed by a slight emergence).

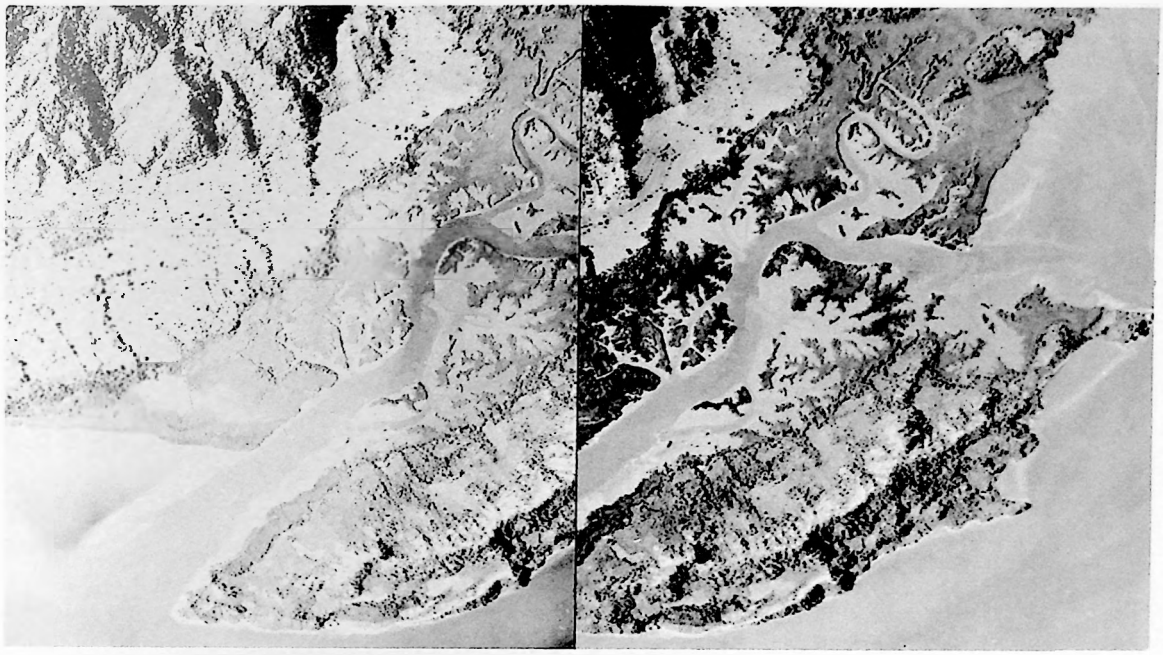


FIG. VII-68. Stereo-pair of photographs of a compound coast (submergence followed by a slight emergence).

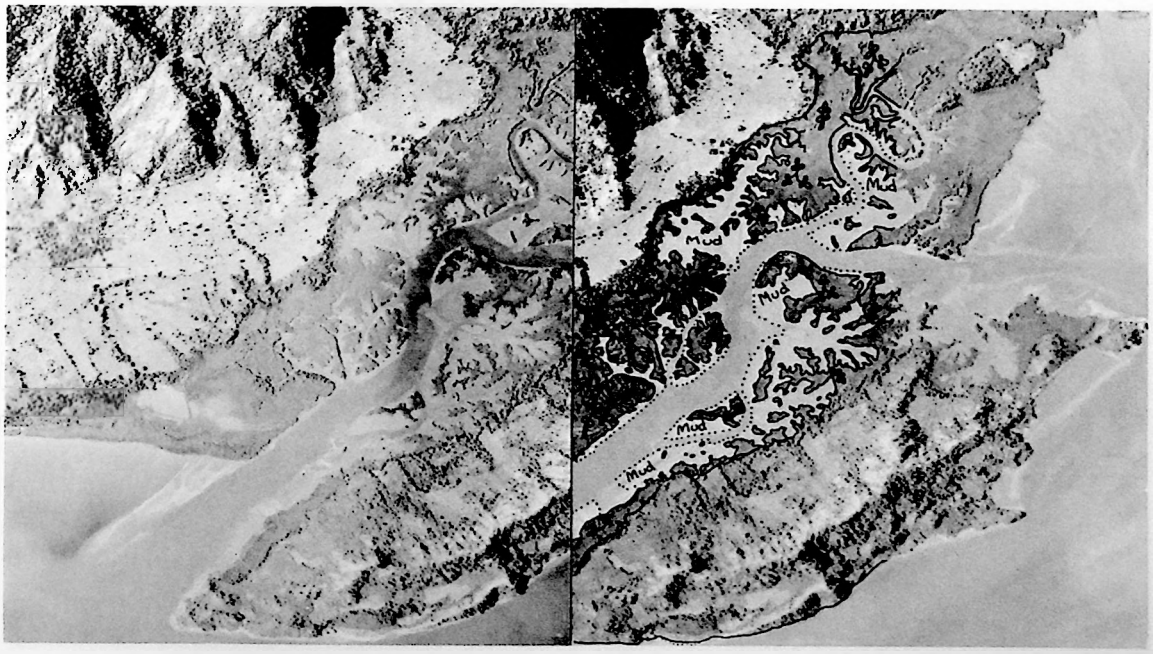


FIG. VII-69. Duplicate of Fig. VII-68 showing an example of delineation of coastal features.

Fig. VII-70 is an oblique aerial photograph of a coastal area which has been altered by man. A portion of the area has been reclaimed and other portions are under the process of being reclaimed. Fig. VII-71 is a stereo-pair of vertical photographs of the area and Fig. VII-72 is the same stereo-pair on which is shown the delineation of coastal features.

FIG. VII-70. Oblique photograph showing a typical coastal area which has been altered by man made features.

FIG. VII-71. Stereo pair of photographs of a typical coastal area which has been altered by man made features.

FIG. VII-72. Duplicate of Fig. VII-71 showing an example of delineation of coastal features.

Fig. VII-73 is an oblique aerial photograph of another coastal area which has been altered by man. Fig. VI -74 is a stereo-pair of vertical photographs of the area and Fig. VII-75 is the same stereo-pair on which is shown the delineation of coastal features. Care must be exercised to avoid including boats and ships in the delineation of areas of this nature.

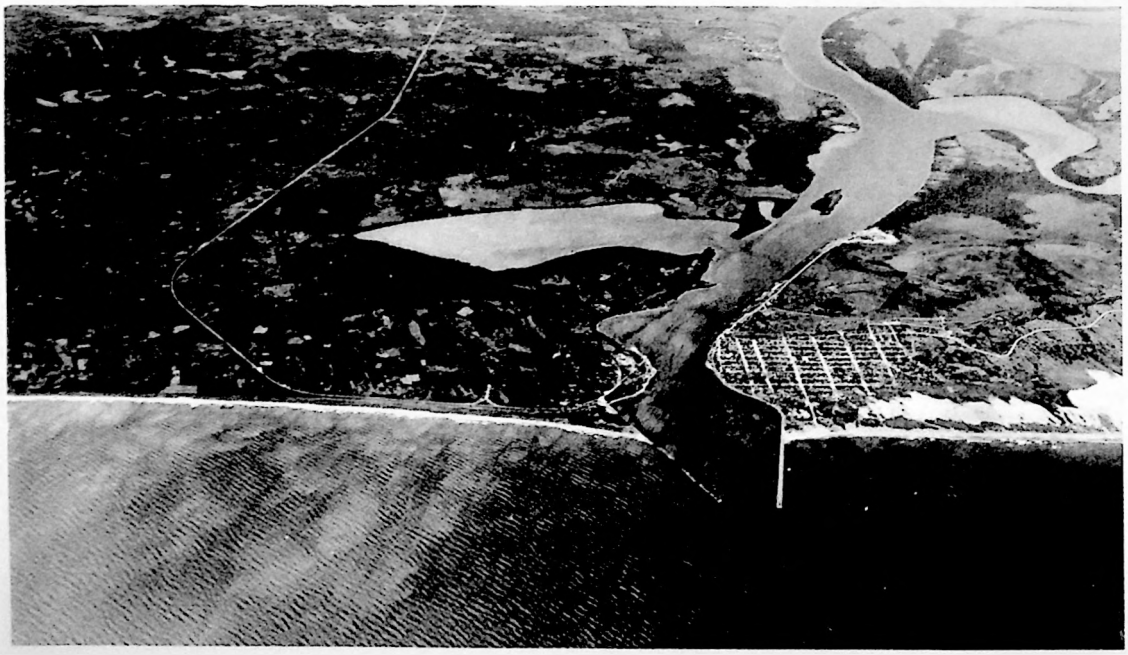


FIG. VII-73. Oblique photograph showing a typical coastal area which has been altered by man made features.

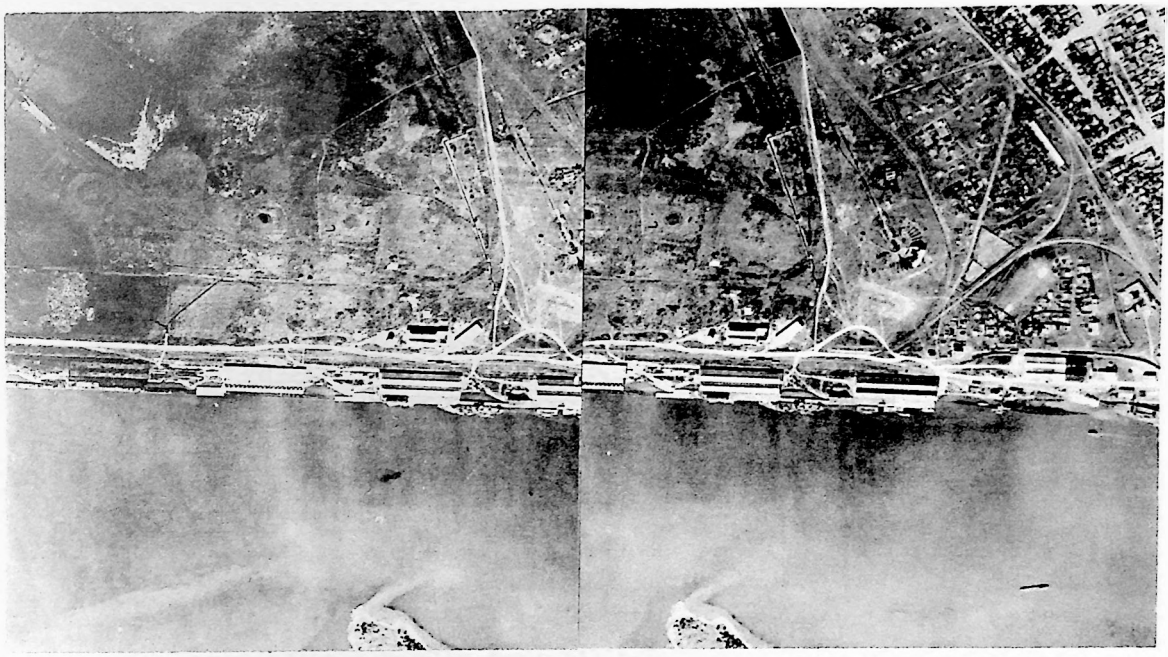


FIG. VII-74. Stereo pair of photographs of a typical coastal area which has been altered by man made features.

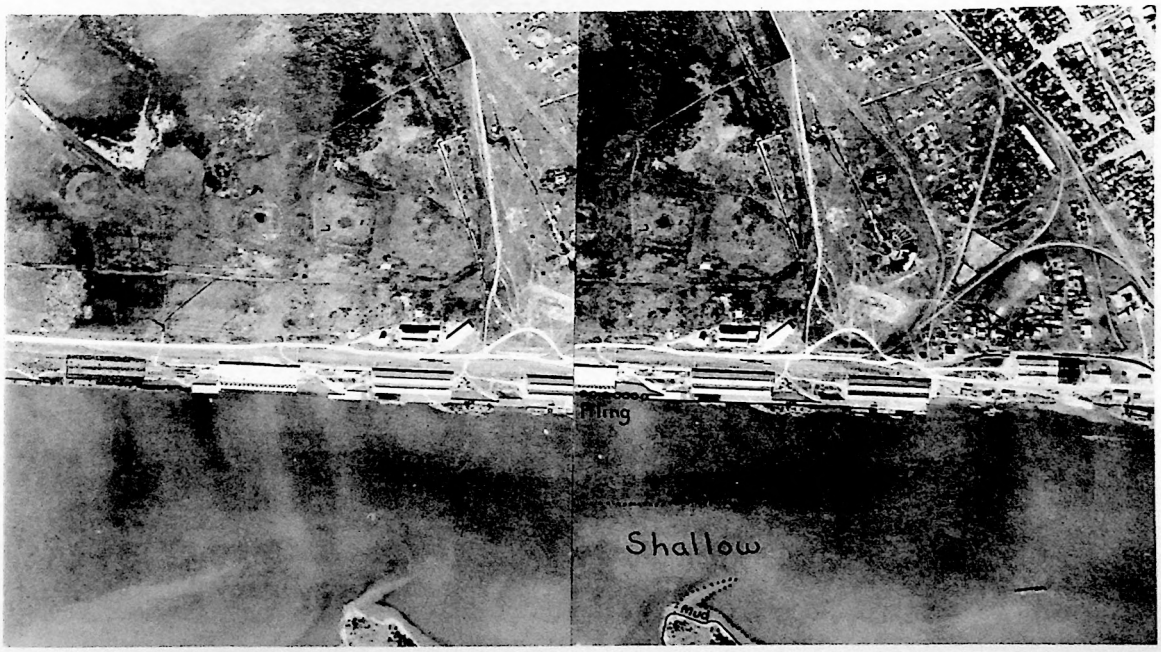


FIG. VII-75. Duplicate of Fig. VII-74 showing an example of delineation of coastal features.

Fig. VII-76 is a vertical photograph of another typical example of a coastal area which has been altered by man. Fig. VII-77 is a stereo-pair of verticals of the area and Fig. VII-78 is the same stereo-pair on which is shown the delineation of coastal features.

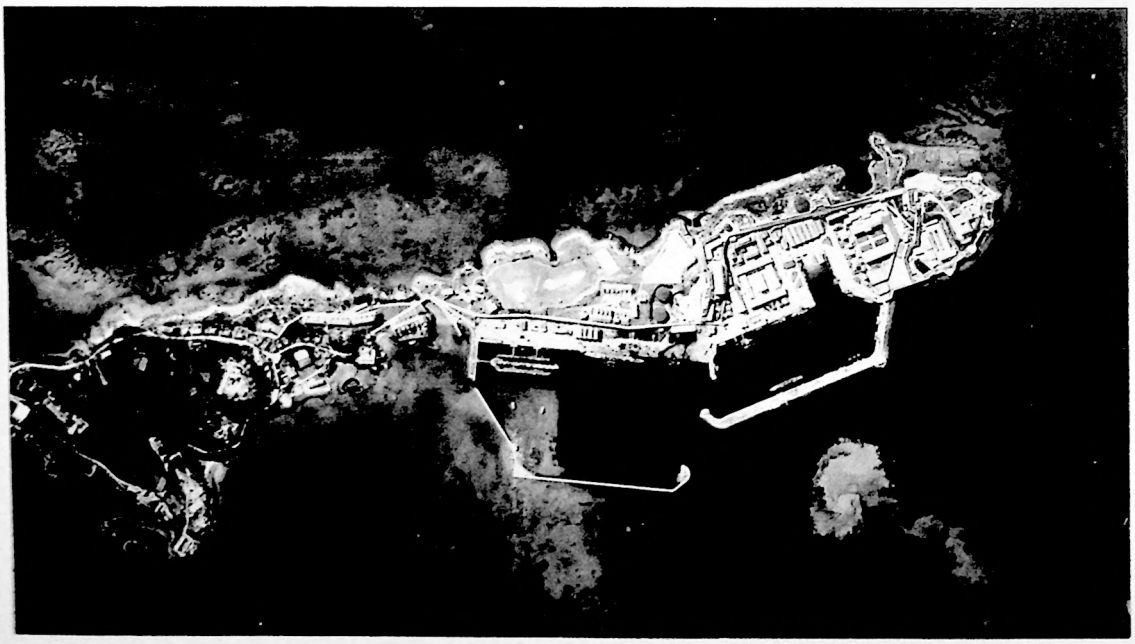


FIG. VII-76. Is a vertical photograph of another typical example of a coastal area which has been altered by man.

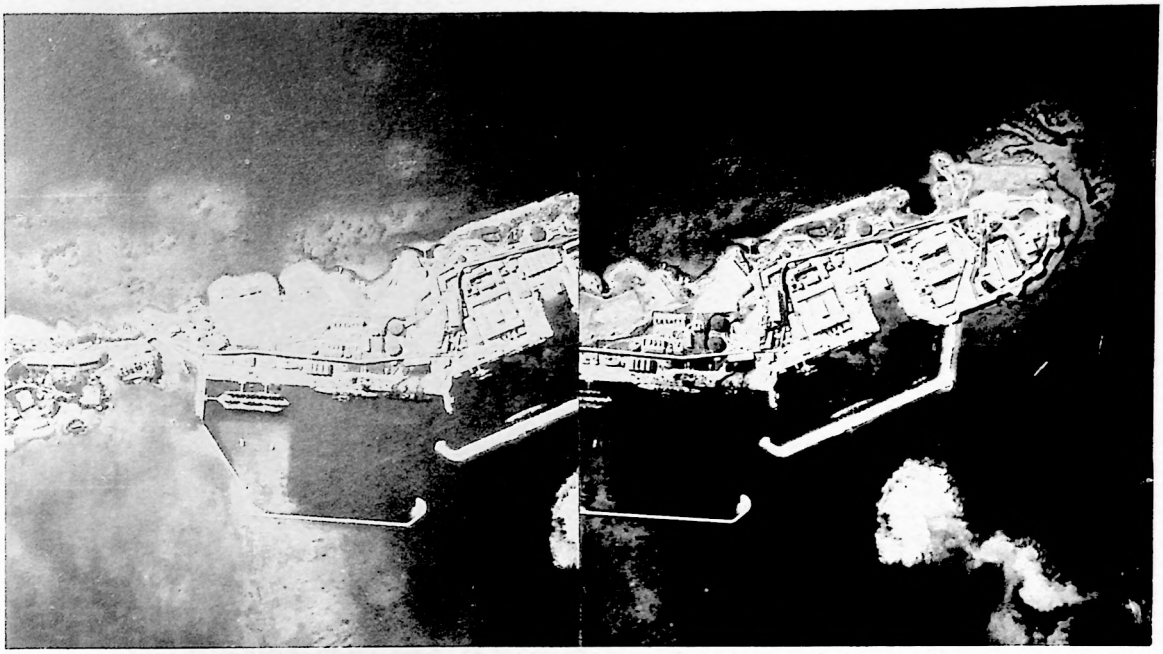


FIG. VII-77 Stereo-pair of photographs of a typical coastal area which has been altered by man made features

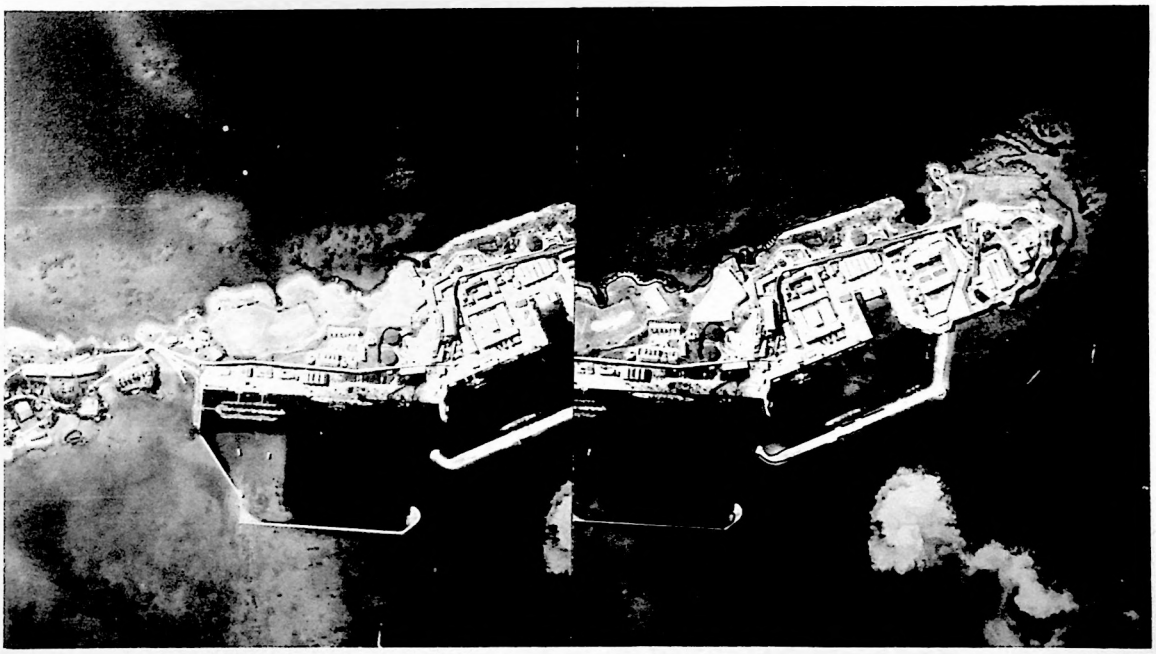


FIG. VII-78. Duplicate of Fig. VII-77 showing an example of delineation of coastal features.

Fig. VII-79 is an oblique aerial photograph of another coastal area which has been altered by man. Fig. VII-80 is a stereo-pair of vertical photographs of the area and Fig. VII-81 is the same stereo-pair on which is shown the delineation of coastal features.

FIG. VII-79. Oblique photograph showing a typical coastal area which has been altered by man made features.

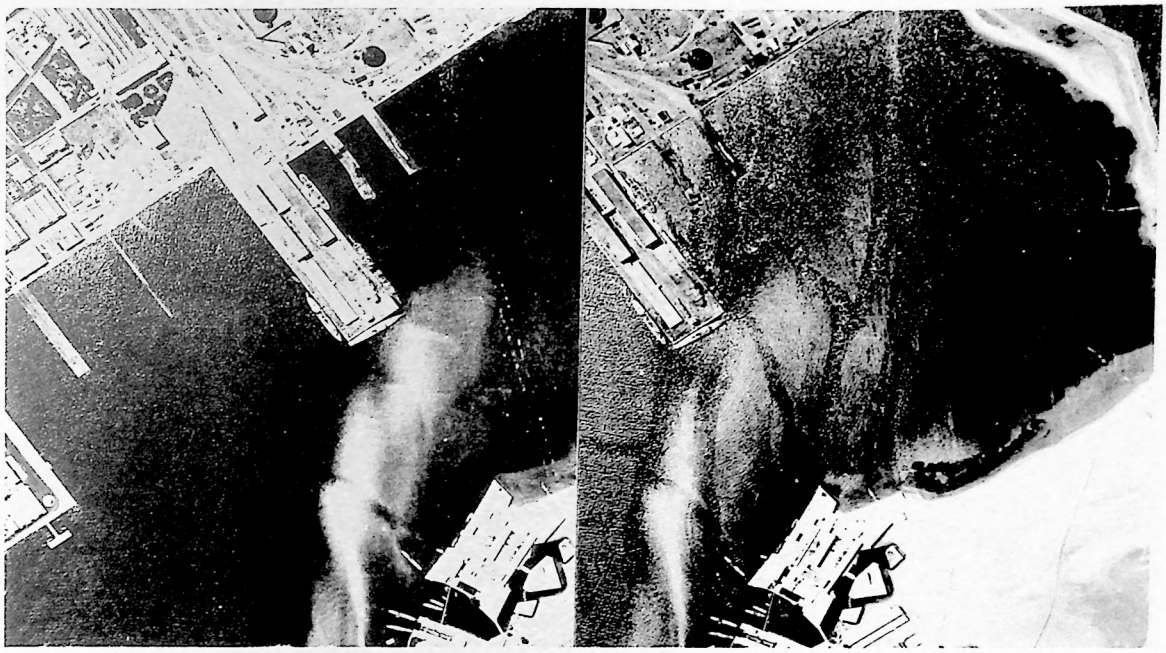


FIG. VII-80. Stereo-pair of photographs of a typical coastal area which has been altered by man made features.

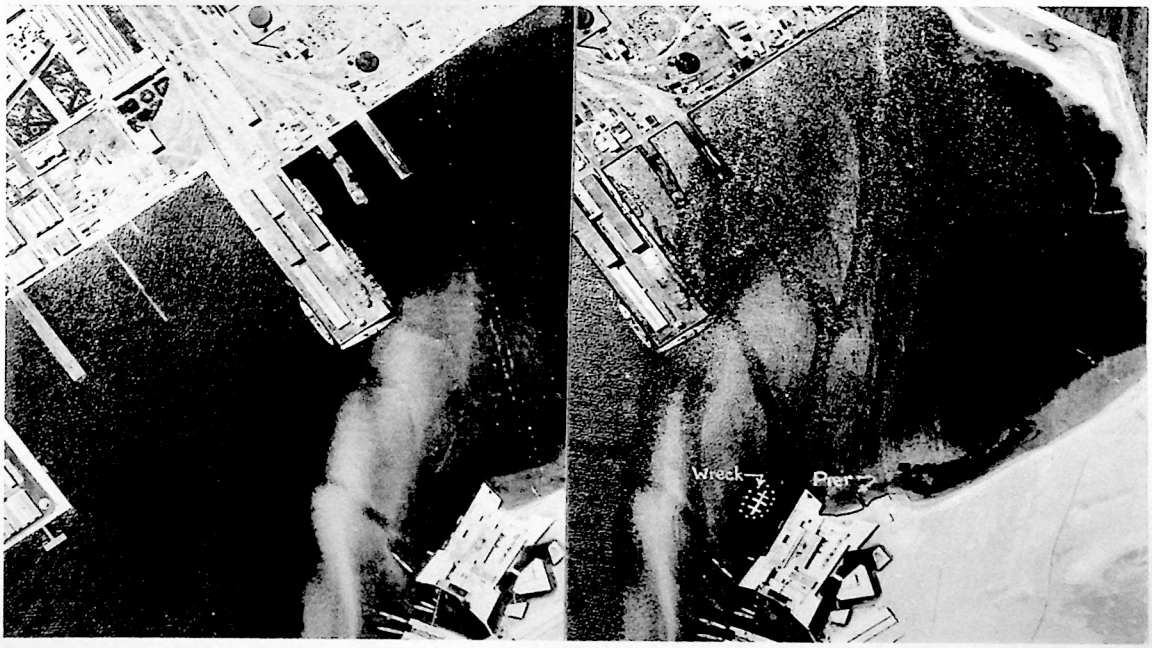


FIG. VII-81. Duplicate of Fig. VII-80 showing an example of delineation of coastal features.

Fig. VII-82 is an oblique aerial photograph of a coastal area which is subject to a wide difference between high and low tide. The accompanying vertical photographs, Figures VII-83 and VII-84 show the effects on an aerial photograph under this condition. The range of tide between high and low water is approximately 40 feet in this area. It will be seen from a study of the vertical photographs that extreme caution must be exercised when delineating coastal features in areas similar to this. Fig. VII-83 is a stereo-pair of vertical photographs of the area taken at approximately low tide and Fig. VII-84 is a stereo-pair of vertical photographs of the area taken at approximately high tide.

FIG. VII-82. Oblique photograph of a coastal area which is subject to a wide difference between high and low tide.

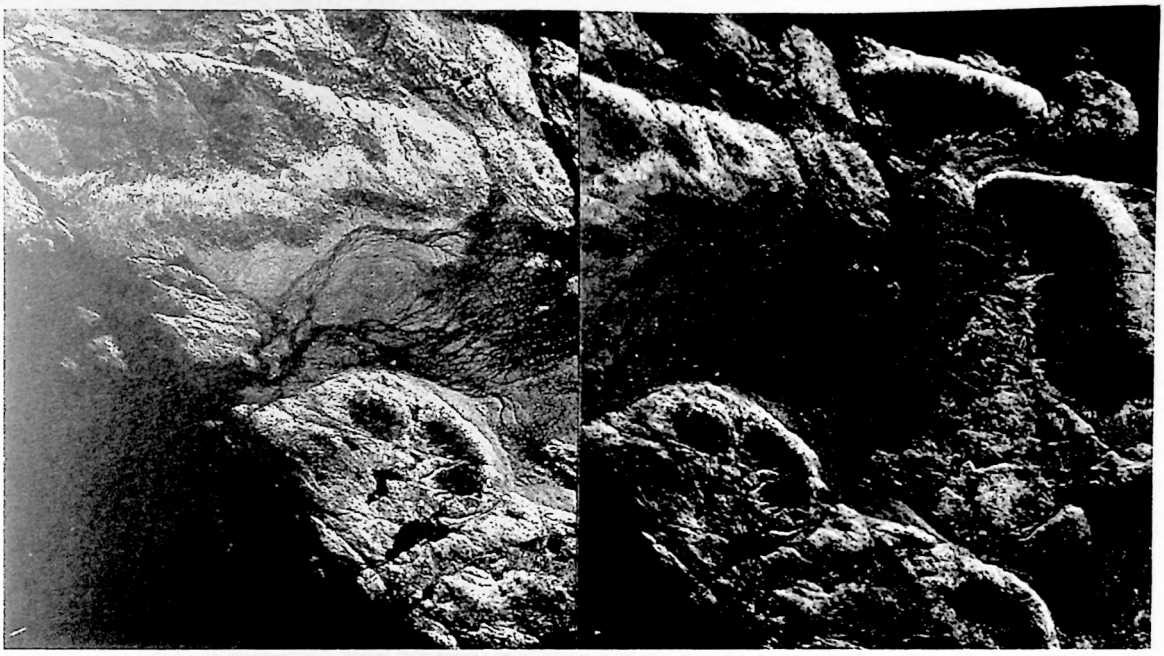


FIG. VII-83. Stereo pair of photographs covering a small portion of the area covered by Fig. VII-82.

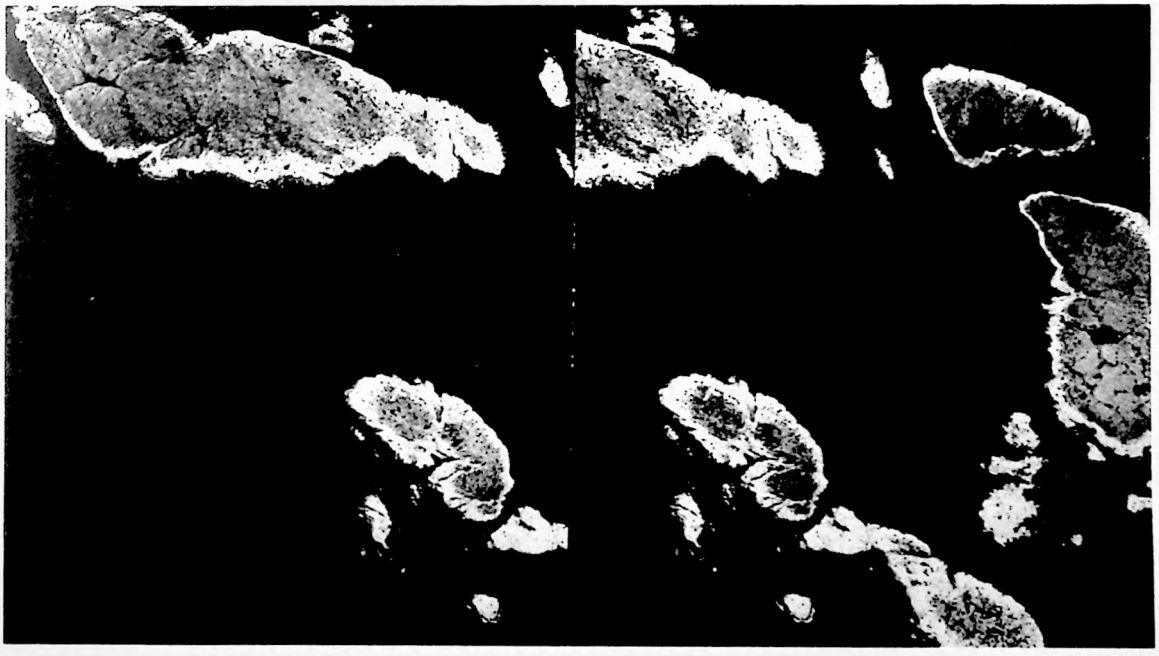


FIG. VII-84. Stereo-pair of photographs covering the same area which is covered by Fig. VII-83.